Bats, Mosquitoes and Dollars

By

Dr. Charles A. R. Campbell

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By DR. CHARLES A. R. CAMPBELL

DEDICATION

TO THE SWEETHEART OP MY BOYHOOD, THE BRIDE OF MY MANHOOD,
THE UNSWERVING QUEEN-MOTHER OP OUR
LITTLE HOME, THIS VOLUME IS LOVINGLY
DEDICATED BY THE
AUTHOR

Preface

The newspapers and the popular magazines have done the world in general, and this country in particular, an inestimable service in diffusing the knowledge of the danger from mosquitoes, for which we owe them, indeed, an undying debt of gratitude. But their warnings have gone unheeded; or, at least, very little attention has been given to the menace of this most malignant of insects.

The author has made a truly intimate study of malaria— in fact, he has limited his private practice to that disease and

typhoid fever; and he here presents to the reader the HOW and WHY of this world-wide malady.

It is not a matter of surprise that someone long ago has not studied and brought to light the wonderful habits of that extraordinary little creature, the bat, when we consider the unpopularity of such an undertaking; for who would undertake the cultivation of bats, except some individual whose stability of intellect might be questioned?—besides, the hard and expensive nocturnal work, coupled with derision and the accusation of being "batty," would alone suffice to account for the fact that this most valuable creature, who deserves to occupy such a high pedestal in the domain of preventive medicine, was passed up by the bearers of me torches of learning.

The value of the bat as a mosquito destroyer was never doubted nor questioned, as we see men high in scientific circles extolling their wonderful and valuable habits; but to attempt their cultivation was a matter that such men left severely alone. In a three-volume publication by the Carnegie Institution of Washington, Washington, D. C., entitled "The Mosquitoes of North and Central America and the West Indies" by Howard,* Dyar, & Knab (1912) on page 179 appears the following:—

* (Howard, L. O. Chief of the Bureau of Entomology, United States Department of Agriculture.)

BATS AS MOSQUITO DESTROYERS

"Bats are important mosquito-destroying animals. Plying at dusk and after dark and capturing all flying insects upon the wing, they devour large numbers of mosquitoes in times of mosquito prevalence. Mr. C. Few Seiss at a meeting of the Feldman Collecting Social in Philadelphia, June 19th, 1901, stated that he had dissected a specimen of the common brown bat (EPTESICUS FUSCUS) and had found its stomach full of mosquitoes. The suggestion has been made by Mr. A. C. Weeks of Brooklyn that an attempt be made to breed bats artificially on account of their importance as mosquito destroyers, but no one seems to have taken the matter up.

"Greatly impressed with the value of bats as mosquito destroyers Dr. Chas. A. R. Campbell, formerly city bacteriologist of San Antonio, Texas, has erected a novel bat-breeding house six miles south of that city. His idea is that the bats will rapidly become so numerous with this admirably-adapted nesting place as to rid the neighborhood of night-flying mosquitoes; and that, at the same time, the entire expense will be more than paid for by having the structure built in such a manner that the bat guano can be readily collected and taken away."

The object of this little volume is to impress the reader with the importance of a badly-named disease, malaria, with which he has been familiar since childhood, and which he probably still views in a spirit of levity. It is sought to impress him with the fact that it is his kind, and his kind only, that is responsible for its perpetuation, and that it is a scheme of

Nature's to use the red corpuscle of man and the body of one of her lowly insects, the malarial mosquito, to serve as intermediary hosts for the continuance and perpetuation of a still lower form of life. This being true, it is the only human disease that Nature, *per se,* does not cure, as she never defeats her own schemes.

It would be of little import to inform the reader of the untold suffering and the colossal economic loss caused the world over by malaria, amounting to a hydra, and thus leave him high and dry; hence the author expounds not merely one of Nature's most wonderful creatures, but THE most wonderful of Nature's creatures, who will do battle and prove to be the Hercules that will slay this Hydra of modern times.

But it is not a battle planned by man, to be followed by terrible suffering, loss of human lives, and frightful devastation: it is to be a faunal battle, planned in the long ago by that infallible strategist, Old Dame Nature, and which has been going on for ages; but only now has the Old Lady been coaxed in the right direction and induced to disclose one of the most important of her innumerable secrets. It is truly a battle royal, marshalled not by that highest of earthly things, the human brain, but by the matchless faculties given by Nature; and, instead of the battle being followed by cruel devastation, the fields of combat have been converted into lands of peace and happiness, and the warriors, not in the least diminished in number but flushed with victory, return to their "garrisons" carrying multitudes of their victims, which later are converted into DOLLARS.

The "garrisons" are the homes of the faunal army, and are called by the author "Bat-roosts;" but they might very fittingly be termed "Palladiums." So well does this natural army do its duty, that, if some individual, from whose soul AVARICE has drained the last drop of the milk of human kindness, in quest of more money, should build such a "Garrison," "Palladium," or "Bat-roost," he unconsciously would be converted into a benefactor.

To this book is added a paper on the "FUNCTIONS OP THE SPLEEN," a study made possible in the course of investigations concerning these creatures. Thus we see, at almost every angle, the little flying mammal exhibiting its nobility, and, in this instance, pointing out to us one of Nature's secrets, the disclosure of which, perhaps, will result in untold benefit to mankind.

The introduction of the study on Dragon Flies and the reason therefor are explained in the work itself.

The motive in adding the work on smallpox and bedbugs will be explained in the foreword thereto, written by the eminent American consulting engineer, Dr. J. A. L. Waddell, whom the author has known for many years, and whose wonderful personality he enjoys the honor and privilege of addressing in correspondence as "My esteemed friend."

In truth, it is to Dr. Waddell that this book owes its existence, for it was he who first suggested its preparation; and, had it not been for his persistent urging and kindly stimulation, the MS. would never have been either begun or completed.

Nor does Dr. Waddell's connection with this book end here; because, mainly for friendship's sake but also in the interest of both science and human welfare, he devoted three full weeks of his valuable time to checking the entire original MS. and polishing its diction, as well as to the verification of the re-typed copy. The author appreciates this aid more deeply than he can express; for he feels that his engineer-friend's labor and advice have materially improved the general character of the treatise.

To the medical profession of San Antonio, Texas, as represented by the Bexar County Medical Society, the author wishes to express his heartfelt thanks for their kind encouragement in the beginning of this work, which has taken 24 years to complete, and for their endorsement of it when finished.

To none of his many staunch laymen supporters is the author more indebted than to that prince of gentlemen, Mr. Frank G. Huntress, the General Manager of the San Antonio Express, who years ago foresaw the vast possibilities in the little bat for good to mankind, and gladly lent his services in liberally granting space in his great daily for its exploitation, thus giving the bat-work wide publicity. The author also feels particularly kindly towards many splendid, amiable, and loyal fellow-citizens of his for their encouragement and good words, which so lightened the weight of the burden induced by many disquieting failures, and made success possible.

Introduction

It is a privilege of the largest moment to write an Introduction to Dr. Charles A. R. Campbell's notable work.

It is many years now, over thirty, since the importance of the subject treated in this book, reached me, as a vague general idea. In an address given before the Canadian Institute of Toronto, in the late 80's, I said, "If you will explain the immunity of the seal and the polar bear from rheumatism, or the freedom of the flamingo and the buffalo from malaria, you are taking the first step toward conferring a like immunity on man." These explanations, I argued, could be made only by slow, persistent, natural-history investigation; and on this fact I founded my claim to the vast ultimate importance of faunal lists as the best methodic approach to natural history, which, at that time, was considered a mere fad of the dilettante.

We have marched on since then. We have learned some of the secrets of malaria; at least its cause, its carriers, and its fearful burden on the human race.

In 1907 I went by land to the Arctic region, where the mosquitoes are more numerous and fierce than in any other country that I have visited. My impressions of those mosquitoes and their terrors, as a scourge to humanity, are thus set forth in my published account.

"After considering the vastness of the region affected—three-quarters of the globe—and the number of diseases that these insects communicate, one is inclined to believe that it might be a greater boon to mankind to extirpate the mosquito, than to stamp out tuberculosis. The latter means death to a considerable portion of our race, the former means hopeless suffering to all mankind; one takes off, each year, its toll of the weaklings, the other spares none; and in the far north, at least, has made a hell on earth of the land that, for six months of each year, might be a human Paradise."

Larger experience and more information incline me, not to modify this statement, but to enlarge and intensify it.

Let us take a map of the globe and blacken those spots where insects have driven man to the wall, robbed him of the joy of life, kept him on the confines, or cursed him with lingering disease. "We are shocked, as we realize visually this ruin of our heritage; for it includes the fairest and most fertile parts of the earth, those blessed above others with a sunny clime; and these insects, in nine cases out of ten, are mosquitoes.

If we had a just appreciation of this condition and its cause, we should have in each town not merely a Health Department, but a Mosquito Department, to marshall all energies in a determined effort to overcome this world-wide curse.

In his chapter on "Dragon Flies—One of Man's Best Friends," Dr. Campbell handles a theme full of present interest and promise for the future. No one can read it without being deeply interested, for the Doctor has indeed opened to us a volume of the fairy tales of science,—fairy tales which have the unusual charm of being possible and true. I personally have not studied these creatures, so that I cannot speak as an authority on the accuracy of his detail, but his broad conclusions are fully demonstrated.

In brief, these facts are outlined for the guidance of future workers. Mosquitoes are a terrible plague, one of the worst afflictions known to mankind. We realize that there must be a remedy, a remedy within the power of mankind to apply successfully. That remedy is in the line of nature's own adjustments; and we are certainly on the way to discover it, if we acquire a complete knowledge of the habits of the mosquitoes and their natural enemies.

Natural history has ever been a delightful and rewarding subject for study; but surely no higher reward has ever been held out than this—the possibility of wiping out the world's mosquito plagues. This surely would rank as one of the

highest achievements of beneficent science.

Any advance toward a solution of the mosquito problem should be hailed by humanity; any step toward a full understanding of it is a move toward a solution. And I welcome this contribution by Dr. Charles A. R. Campbell, as one of the most comprehensive, intelligent, and revolutionary examinations of the question ever offered to the public.

ERNEST THOMPSON SETON.

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PART I

Bats, Mosquitoes, and Dollars

It seems at first glance rather singular that long ago some one had not thought of and demonstrated the value of the common little bat, and placed it on the high pedestal in the domain of preventive medicine which it so richly deserves. But when we consider, as said in the preface of this volume, the unpopularity of such work, coupled with much derision and many accusations of being "batty," plus exceedingly hard and expensive work, that combination will account for the delay in our knowledge of its remarkable habits, of which habits we can take advantage to a complete usufruct.

Prom time immemorial the bat has been considered a "thing of evil." The ancient poets and painters, while giving the benign spirits and angels the beautiful white, symmetrical wings of birds, for contrast, or in obedience to the poetic principle, gave to the malignant spirits and demons the dark and sombre wings of a bat; hence this truly valuable creature has always had a most unenviable reputation, plutonic in character. The little Catholic child in its catechism book, and the Protestant child in its Sunday-school book, see the pictures of angels with the beautiful bird-wings, and the devil and all of his kind with bat-wings. It, therefore, is perfectly natural that deep-seated prejudice against this beneficent creature should exist in the tender mind, and at a time when it leaves the deepest and most ineradicable imprint.

The bat is given recognition in the Bible, but again unenviable, as it is classed as "unclean." That recognition is found in Leviticus, 11th Chapter, 19th verse, and in Deuteronomy, 14th Chapter, 18th verse.

In the small readers and fable books some kindly mention is made of the bat's distant cousin, the mouse; where the mother mouse warns her babies about the cheese in the trap; how the little mouse gnawed in twain the strands of the rope that held the lion captive and so liberated the king of beasts, etc. Has any one ever written or said one kind word for the little bat? Yet the little bat does not gnaw its way into our homes, destroy and consume our food, ruin our clothes and furniture or the piano, or bring us fleas and with them, perhaps, the bubonic plague, but while we are asleep and unconscious of danger, our little friend is protecting us by working all night long seeking and destroying one of our greatest enemies, that most malevolent of insects, the malaria mosquito.

There are perhaps very few or none of Nature's creatures that offer more anomalies, or present more difficulties for

study, than the common bat. The author began to investigate these creatures in the year 1900, though the idea had been conceived the year previous. About that time he was at work on the practical application of a theory he had evolved, viz., that smallpox, then considered so "easy-catching," so infectious, and so contagious that even touching the clothing or breathing the air of a room occupied by a person afflicted with the disease was equivalent to acquiring it, was not so transmitted; that the panic a case of smallpox occasions and the resultant quarantine are entirely unnecessary and uncalled for, as the disease, like malaria, is insect-born, and carried only by bedbugs, and that the pitting or pocking can be prevented.

Smallpox being essentially a disease of the winter, and bats being dormant, or hibernating during that time, the author considered himself rather fortunate in that the two problems he had laid out for himself possessed such happy peculiarities, because he could engage in the study of smallpox and bedbugs in the winter, and of malaria and bats during the summer.

The smallpox-bedbug work in a few winters had reached that degree of perfection to warrant its being brought to the attention of the medical profession of San Antonio, as represented by the Bexar County Medical Society, on which occasion the author was honored by being given a rising vote of thanks. The Society also appointed a standing committee to continue the research, which committee is in existence today. Some day the author will publish the bedbug work in full.

The bat work, however, was not only of far greater importance, but much more fascinating, on account of the difficulties presented, as working in the darkness and serenity of the night gave it an air bordering on the fantastic.

In addition to all these years of valuable time contributed to the study of the matter, the investigation has cost many, many thousands of dollars.

The proposition of the cultivation of bats has two separate and distinct values. One of these is hygienic, the other commercial; but these two values are inseparable, and the practical application and demonstration of them has been accomplished by a small bat-roost which the author and owner intended to serve only as a means of demonstrating the fact that bats, like bees, could be colonized and cultivated, but never even dreaming at first that such a small structure could achieve such astonishing results.

The Government sends its agents into the most remote parts of the world to find some insect that preys upon the parasitic insects infesting fruit trees, thereby saving thousands of dollars to the fruit industry; but in the little bat we have right at home a friend whose wonderful habits we can take advantage of in the saving of precious human lives, and, at the same time, line our pockets with gold.

Before entering upon the work proving the two values mentioned, and with the view of making this little book a study as well as interesting reading, the author has divided the said work into four parts, which he has termed "Allegations." How well the allegations are proved, or what portion of the work appeals most to the reader, is left entirely to the latter.

ALLEGATION ONE:—That the malarial mosquito is one of the greatest enemies of mankind.

ALLEGATION TWO:—That the bat is one of man's best friends, because it so relentlessly destroys the malarial mosquito, that insect being its natural and principal food.

ALLEGATION THREE:—That we can build a home for bats in a scientific manner to meet the requirements of their most singular habits, and one which they will inhabit; a home where, being protected from their natural 'enemies, they will increase in countless numbers and eradicate the malaria in its vicinity.

ALLEGATION FOUR:—That each bat roost, in addition to its great hygienic value, is in itself a little gold mine, by reason of the cash obtained from the natural high-grade fertilizer, guano, which it will constantly produce.

Allegation One

That the malarial mosquito is unquestionably one of the greatest enemies of mankind

IMPORTANCE OF MALARIA

To estimate the loss attributable to malaria throughout the world is impossible of anything approaching accuracy. The most distinguished observers and scientists of Italy sum up the situation in that country with the statement that "Malaria costs Italy annually untold treasure." Leslie, an English investigator, estimates the mortality in India from this cause at 1,030,000 persons annually in what is termed "an ordinary malarial year." Dr. Ross, the great scientific luminary, has estimated that in the population of Greece, amounting to 2,500,000 inhabitants, there are 900,000 cases of malaria; and he attributes the degeneracy of that great race of people to their being so generally afflicted with malaria. Scientific men estimate the loss from malaria in this glorious country of ours at $250,000,000 annually; and this estimate is said to be very conservative.

Our own Dr. W. A. Davis, the able Secretary of the Texas State Board of Health, in a report to that Board, has estimated the loss from malaria in his state alone at millions of dollars. The same area of territory as that requisite to grow the North American cotton crop, some 79,000,000 acres, which are as fertile as the delta of the Nile, lie dormant and uninhabitable on account of mosquitoes and malaria.

We import two million ounces of quinine for home consumption annually, in addition to the 2,500,000 ounces which we make ourselves. It would be very conservative to state that there are 20,000,000 bottles of "chill medicine" in one form or another consumed in the United States every year. Every druggist makes his own favorite chill medicine, or has it made for him; and there is hardly a little country store that has not a small stock of anti-malarial medication.

Malaria, ague, chills-and-fever, dumb chills, intermittent fever, are the common names of this very-wide-spread disease. The word "malaria," which means bad air, was given to this sickness by an Italian writer in 1753. It was supposed to be contracted by inhaling the thick, damp air common around swamps and lowlands. It has been suggested that the name "mosquito fever" be adopted; a position well taken, when we consider the complete knowledge we have of the disease at the present day.

The literature on malaria is enormous. Several thousand books and articles have been written; but, with the exception of

one, all deal with the transmission of the disease to man, and from man back to the mosquito, etc. As far as the writer has been able to ascertain, only one book has appeared on the influence of malaria upon history, though eighty years ago, MacCulloch, a brilliant English observer, complained of the great indifference displayed by Englishmen to the damage caused by that scourge. The disease was known one thousand years B. C.; but it was only in the year 1880 that a distinguished Frenchman, Lavaran, discovered the parasite.

Columns could be written on the effect of this disease upon the different people of antiquity since its earliest recognition ; and their methods of its treatment ranged from tortoise blood, alligator dung, and crushed spiders, to religion, magic, and charms. With such therapeutic agents in combating a disease, the origin of which was entirely unknown to the ancient world, it is no wonder that the rise and fall of nations can be attributed to it; nor are the popularity of the dream-oracle, the belief in charms, and the superstitions of the cultured classes to be wondered at, when without the proper remedies, or the understanding of them, malaria was on the increase.

The most illustrious sufferer in the long ago is mentioned by Ramsey in his book, "The Church in the Roman Empire," page 64, in which he holds that St. Paul was a victim of malaria, and the disease is referred to as the "thorn in the flesh."

Malaria is caused by a greater or less multitude of animal parasites which penetrate and occupy the red corpuscles of their human host, destroying those they occupy, *and* producing an anemia, or poverty of blood, and other disorders. In some cases the parasite may remain in the body for years with no manifestation of fever to warn its host of its presence, though it is continually undermining his health. The disease is transmitted by certain mosquitoes belonging to the genus Anopheles, and can be contracted in no other way.

Most of the diseases with which the layman is acquainted are bacterial, which means that they are produced by bacteria. The terms bacteria, germs, microbes, microorganism, are all synonymous. The bacteria are defined as "the lowest of all organized forms of life." Typhoid fever, measles, scarlet fever, smallpox, whooping cough, etc., are bacterial diseases; and most of them, as a rule, attack but once, and, by a very complicated process, confer an immunity.

CAUSE OF MALARIA

The causative agent of malaria does not come within the definition of the bacteria, as it belongs higher up in the type of life, being classified as a protozoan. This is defined as "A collective term for the lowest members of the animal kingdom, distinguished by their simplicity of structure, etc."

As we speak by comparison in order better to convey or enforce our thoughts, let us make a comparison for the blood-

stream coursing through our bodies, nourishing all the different organs. If we had a large moving trough, at which all kinds of animals waited to be fed, we, of course, would have to provide and place therein the different foods suitable to the different species of creatures. The lion would not care for the hay—he would wait until the meat got around; the dog would refuse the corn, but the horse would not; the cat would not eat the nuts, but the squirrel would, and so on. Imagine what complexity of material the blood must have when it has to nourish the liver with what it needs, the heart with what it needs, and so on; and that blood to contain an animal parasite feeding on it, which, being a living thing, performs physiological functions, necessitates that its effete products are thrown into the blood, and that the different organs and tissues must be nourished on that poisoned blood. In addition to this, as was stated previously, "the parasite penetrates and occupies the red corpuscles of the human host, destroying those it occupies and producing an anemia." The individual infected with malaria soon acquires a constitutional perversion of nutrition, which is known as the malarial cachexia. The word cachexia is very commonly used in the Spanish language to denote a person in a run-down condition, characterized by a muddy or sallow complexion, or of a general unhealthy appearance. As we shall have occasion to use the word quite frequently in this Allegation, the reader will kindly keep it in mind.

MALARIAL CACHEXIA

As has been said, the malarial parasite selects the red corpuscle as its normal habitat, but it does not merely occupy the corpuscle—it gets its nourishment from its contents, and when these are exhausted, it ruptures the corpuscle, and immediately enters another, and another, and so on, destroying each as it leaves. This corpuscular destruction soon begins to leave its imprint on the body, and the infected person acquires a poverty of blood which, as said before, receives the technical name of anemia.

Now, it is this condition that brings about the malarial cachexia. A person with this perversion of nutrition has hanging over him a veritable sword of Damocles, as his body-resistance is so greatly reduced that he becomes very susceptible to any of the important bacterial diseases. If such a person acquire typhoid fever, pneumonia, or some other microbic disease, he is, indeed, in a very serious condition; for he has been infected with another very powerful devitalizing agent, and now has two to contend against.

This does not mean that a person infected with malaria and its cachexia has an aversion for food, but that he is run down, has usually an earthy sallowness of the skin, and a generally unhealthy appearance, particularly when compared with a person of strong, rosy, robust constitution. In the body of such an ailing person the activity of the trillions of minute cells, of which the said body is composed, is at a low ebb. Those wonderful natural phenomena by which all the tissues of the

body are nourished are sluggish in allowing nutritive material to pass in and out of the cells. Consequently we are confronted with a low grade of nutrition; and the malarial subject, though not necessarily ill, suffers not from a lack of harmonious action on the part of the body-cells, but from a low pitch of that harmony, or from lack of tone. All of this is due to the enormous destruction of the red corpuscles and because of the toxins thrown off and other damage done by the malarial parasite. It is comparatively easy, even for a layman, to distinguish that particular condition in regions notoriously malarial. But in communities not notoriously, malarial, the disease is not recognized as such, perhaps on account of the prevailing belief that there is no malaria in that community.

The malarial cachexia, or that particular constitutional perversion of nutrition which accompanies the chronic form, manifests itself in hundreds of ways. For instance, the infected person may experience today no ache or pain,—in fact, as he might say, "never felt better." Tomorrow he may feel so bad that he must drive himself to his work. Perhaps he awakens in the morning apparently perfectly well, though during the day he may have a yawning spell, or have cold shivers running down his back. He may become nervous to the extent of neglecting his work, or of snapping at his best friend, or he may get a bad case of the "blues." If inclined to take an "occasional" drink, at this particular time he might take two or three, which will restore his feeling to the false normal. The alcoholic stimulation tends to overcome the depression due to the fact that the parasites were at that time sporolating (which means breeding or hatching) and pouring into the blood-stream millions of their own kind with the concomitant debris.

In women with this infection the nervous manifestations are much varied; displays of temper and depression, physical as well as mental, are very common; these spells, however, may not be characteristic of the woman, but are symptoms of malarial poisoning, and are entirely concomitant with the cycle of evolution of the parasite. Perhaps, the day following, the feelings and conduct of this same woman will be so radically different from those of the day before that she might be referred to as "the sweetest thing on earth." Of course, weeping is a necessary accompaniment.

Women who have everything in life to live for, in fact, "in life's green spring," very often, though unconsciously, cause little ripples of discontent to flow into their homes by exhibitions of the "blues," which perhaps may lead to waves of discordancy. As the malarial manifestation usually follows the multiple of seven, depending on the type, at certain times she might attribute her depression or ill feeling to the approach or establishment of the normal physiological function peculiar to her sex, which, in fact, has no more to do with her ill feeling than have the reflected rays of the moon.

If her malarial manifestation is in the form of a sick headache, or facial neuralgia, she resorts for relief to the different "ines," antipyrine, exalgine, antifebrine, 'etc. She adds

fuel to the fire by attacking the symptoms of a cause with poisons which strike directly at the red corpuscles, already badly crippled by the malarial parasite. If she should be so unfortunate as to find relief in that most seductive of drugs, morphine, it is only a question of time when she becomes an habitue; and then self-respect, family, home, friends, and everything held dear are thrown to the winds.

As it is popularly believed that malaria is necessarily accompanied by fever, it should be impressed on the laity that fever is not a necessary antecedent or accompaniment of chronic malaria or its cachexia. In notoriously malarial regions it is by no means unusual to see typical examples of this condition in which fever never has been a feature, or is of a mild character, or had occurred in childhood and had been forgotten. The subject of this cachexia can go on for an indefinite period without any manifestations until he experiences a severe exposure or fatigue, or until some profound emotion or physiological strain occurs, when the parasite is again fanned into activity.

To mention some of the most common symptoms of the malarial cachexia, it might be said that, in the growing child, its development, both mental and physical, is delayed, and the general growth of the body is stunted. Neuralgia, stomach disorders, vomiting, diarrhoea, headaches, attacks of palpitation, sneezing, general lassitude, the spitting of blood, nose bleeding, and retinal hemorrhage are not infrequent. The malarial subject is apt to be dyseptic; to suffer from irregularities of the bowels, or from diarrhoea. On account of long-standing congestion, associated with anemia, the blood-making organs become diseased; and then, in spite of the removal of the malarial influences, the trouble inevitably progresses to a fatal issue.

The large amount of toxins thrown off by the parasite, with the countless millions of destroyed red corpuscles which the phagocytes carry for elimination to the alimentary canal, cause the infected individual to feel "achy" or generally bad, when he proceeds to the making of his own diagnosis, by charging himself with being "bilious," a term as vague as it is popular.

In the acute form of malaria the diagnosis is indeed a matter of no difficulty at all, but in the chronic form, and with its cachexia, it is quite a different matter. The microscope is a most unsatisfactory instrument to depend upon. Often the infected individual is assured of his non-infection by a microscopic examination of his blood, when he may have numbers of colonies ensconced in his system. The damage done by such a wrong diagnosis is self-evident. This noble instrument, however, does reveal another of Nature's secrets, and so furnishes protection from the malarial parasite.

If we examine microscopically the blood of an individual infected with an acute case of malaria, we shall have no difficulty in finding the parasites; but, after administering only one dose of any of the anti-malarial remedies, such as quinine,

cinchonidia, or any derivative of the Peruvian bark, they leave the circulation, and no amount of the most assiduous work on the part of the most expert microscopist could find a single one. Have they been killed out by the quinine or cinchonidia? By no means. They disappear from the blood stream until the remedies applied have been eliminated, when they return and can be easily found.

A radical change of climate or a long sea voyage will cause this ensconcing, with, of course, a bettered condition of health following. When, however, the individual returns to his usual avocations and duties which call for mental and physical energy, he relapses into his old condition, because the parasites have found their way back into his bloodstream, in order to reproduce; and again they establish their cycle of evolution—all of which can be easily demonstrated by the microscope.

A sojourn at a mineral spring or health resort will sometimes cause the ensconcing, as the individual usually goes to such a place for the express purpose of resting, and leaves all care behind. The purgative or laxative effect of the water, with perhaps the large quantities drunk on account of the high reputation of its curative value, simply flush his entire system and rid it of products that have already served their purpose in the body and are pent up. This sojourn betters his condition by making him more resistant to germ and parasitic influences. Old Dame Nature knows this, and, therefore, to protect the malarial parasite, she causes it to hide away.

If the microscope does not show the parasite in any of its different forms, then, of course, the diagnosis becomes positive. The diagnosis is difficult in the so-called "latent stage," which is a predominating factor for the perpetuation of the disease.

The newspapers and popular magazines have rendered a great service in diffusing the knowledge that mosquitoes transmit malaria, but they have in the past very much neglected MAN as a focus of infection.

MALARIAL CARRIERS

A distinguished writer says: "It is a common occurrence to find the parasite in the blood of patients. These patients are malarial carriers, who perpetuate the disease in those sections where meteorological conditions are such as to destroy the parasite in the mosquito during the winter months, and are a most serious factor in any community considering a campaign against this disease. Malarial carriers are absolutely responsible for the perpetuation of the disease in temperate climates, where the mosquito becomes free from infection during the winter months. The latent carrier also largely enters into the dissemination of the disorder even in tropical countries; and it cannot be emphasized too strongly that the destruction of the parasites in these carriers is equally as important as the destruction of the mosquito."

While this would be most desirable, it can be seen at a glance how impractical of application this is, since in some communities from 50 to 100 per cent of the inhabitants are infected, and as no one would consent to take a long course of anti-malarial medication, particularly when he "appears to be suffering no inconvenience as a result of harboring the parasites."

While we know positively that the nocturnal variety of mosquitoes termed *anophelines* convey malaria, we are not positive that other varieties do not convey it, so that the geographical range of malaria can be placed on this hemisphere as extending from Alaska to Patagonia.

UNIVERSAL OCCURRENCE AND POPULAR TREATMENT OF MALARIA

It is a mistake for some communities to assume that they have no malaria among them; because the reports from the medical profession to the health officer are necessarily incomplete, for the reason that the disease, chills and fever or malaria, on account of being so well known, is self-diagnosed and largely self-treated. This is due to well-directed advertising on the part of the patent medicine industry, the familiarity of the laity with the disease, and the apparent and supposed cures these medicines effect. Surely a person who has stopped his chills with a bottle of such medication, and has thereby saved a doctor's bill, remains a firm believer in its efficacy. He little knows that he is converting his acute case into a chronic one with its accompanying cachexia, and himself into a carrier.

The best evidence of the great prevalence among the laity of this self-practice in malaria is the fact that there are sold in the United States annually, not hundreds, nor thousands, of such bottles of chill cures, but MILLIONS. In addition to the much advertised and so better-known brands of chill medicine, every druggist makes, or has made for him, his own malarial cure, which really is just as good as the patented article. His own cure, affording a larger profit, is given preference, and is unhesitatingly recommended to his customers as a sure cure for chills-and-fever.

All these medications have the same effect, viz., stopping the chills, but perpetuating the disease. It is this class of carriers that the health authorities never hear about, hence it can be seen at a glance that reliable statistics on malaria in any given community are almost impossible. The medications usually contain some derivative of the Peruvian bark, such as quinine, cinchonidia, etc., some of them rendered tasteless by chemical manipulations, which make them better sellers. A return of the malarial symptoms is sure to bring about the purchase of another bottle, which again stops the chills by causing the ensconcing of the parasites; but in the meantime that person is not only infecting all of the mosquitoes that bite him, perhaps transmitting the disease to his family, but is also most effectively aiding in perpetuating malaria.

Some years ago, the writer addressed letters with stamped envelopes to health officers in many towns and cities in every state in the Union, containing this short questionnaire: "Have you any malaria in your community?" "What is the mortality?" "These questions are asked in the interest of science and medical research." Another letter, addressed to the postmaster of every town or city reporting "No malaria," was sent requesting him kindly to hand the enclosed self-addressed and stamped envelop to the most prominent druggist for reply. These letters contained the following question: "How many bottles of all kinds of chills-and-fever, or malaria, medicines, do you sell in a year ? An approximate number will do. This question is asked purely in the interest of science and medical research.'"

Not a single one of those answering from the same cities and towns in respect to which the health officer declared "No malaria here" confirmed the statement. But they all reported one or more different kinds of chill medicines sold. Hence it can be seen that hardly any community, large or small, can be said to be free from this world-wide disease.

COMMON SOURCES OF MALARIA

In stamping out any disease, the sources, or foci, of infection must first be found. For instance, in stamping out yellow fever, also a mosquito-borne disease, with its notorious and swift epidemicity, if we are fortunate in discovering the first case, the sufferer is immediately isolated, or, better said, screened with mosquito netting, to keep the mosquitoes from biting him. If this is done for the first few days after the onset of the disease, which manifests itself in no uncertain manner, that case ceases to be a source of infection, as, after a short period of time has elapsed, the mosquitoes that bite that patient will not be infected, and thus a threatened epidemic is nipped in the bud. Should the individual recover from his attack of yellow fever, he not only ceases to be a carrier, but is immune to the disease. This, unfortunately, does not apply to malaria, as the infected individual continues to be indefinitely a carrier.

It is among the poorer classes where we find malaria most prevalent, because they live in small, cheap-rent houses; and, knowing nothing about the danger of mosquitoes, do not bother about screens, or are too poor to buy them. On hot summer nights, they sleep, perhaps, upon a quilt on the front or back gallery, to escape the heat of the room, and, therefore, are more exposed to mosquitoes. The man with a little more of this world's goods than his poorer brother also pays his tribute to malaria when he goes with his family for a short camping trip to the stream or lake nearest his home. He usually leaves on Saturday afternoon, spending that night and the next day in the woods, returning Sunday night, in order to resume his duties the next morning. Little does this man count on the indirect cost of the camping trip, when he is exposing himself at his trot and set-lines, and when his family is using "mosquito lotions" to be able to sleep. The lotions evaporate about the time the

campers are fast asleep, and the mosquitoes bite and inoculate without hindrance from volatile oils, or from being slapped at.

The rich man, like his poorer brothers, also pays his tribute to malaria when he takes his family during the summer for a camping trip, or a long overland journey, leisurely made by camping and fishing along the mountain streams *en route.* This man carefully plans his trip, and omits nothing, except mosquito bars, that might add to the pleasure and comfort of his family. These bars would afford protection to some of his family, but not to those of them fond of fishing at night; and the fisherman insures his infection by carrying a lantern, which attracts mosquitoes to him. With the advent of winter, some of the family become ill of malaria; he wonders how that is possible, and refers with pride to the fact that his home is screened and mosquito-proof from cellar to garret.

It has come under the author's professional observation that, as good roads are being opened up, the automobile is becoming more and more a most powerful ally of malaria. Time and distance have been annihilated by this great invention, so that the favorite bathing place, camping ground, or fishing resort is at best a matter of but a few hours from the crowded city. The more beautiful and inviting the place, the more certain it is to be sought after, particularly if some near-by farm is handy to furnish the indispensable eggs, milk, etc.

Would the reader go to such a place with family and friends for an outing, if he knew that smallpox had broken out among the people camping there last? Unthinkable! Yet some of those camping there last were malarial carriers and infected the mosquitoes; and, sufficient time having elapsed for the cycle of evolution to complete itself in the body of the mosquito, the disease, malaria, can be contracted by your family and friends with much greater certainty than the smallpox would have been transmitted.

The trans-country, automobile tourist going leisurely through the country, on reaching such a beautiful, shaded place with the banks of the limpid stream freed by previous campers from weeds and underbrush, concludes he has found the ideal location for a long rest in order to clean up, make necessary repairs to his machine, etc.,—in fact, for a while he doesn't wish to go any farther. Little does he realize that he or some of his family will soon be carriers of malaria, and, if they remain at that beautiful place long enough, will indirectly infect others who come there after their departure, thereby unconsciously aiding and abetting Nature in the enforcement of her inexorable laws.

Owing to the new order of things coming very much into vogue, the camping automobilist need not in the least worry about where he is going to camp or how desirable the place will be at his next stop, as camp-sites are being provided by different municipalities which are ideal for just this purpose—all of this being made possible by the automobile.

These sites are arranged along the shaded banks of beautiful streams, which are not only cleared of all weeds and rubbish, but are made more inviting by providing fire places, tables, benches, etc., for the comfort of the campers.

In quite a number of instances, screened and floored tents, or neat little cottages nicely furnished are to be found on the banks of the crystalline stream, so that the camper can save himself the annoyance of over-loading his machine with camping accoutrements. Here the camper finds the acme of outdoor life —back to Nature—varying the monotony by visits to the city or town nearby to replenish the larder, to attend church, visit the movies, or see a game of baseball. In fact, he and his family are enjoying their nomadic life with a minimum of inconvenience.

But living "next to Nature," becoming her guest, as it were, means to accept the Old Lady as she is, and not as we would like her to be; so the campers must unwillingly mingle with her other creatures, the most undesirable of these being the malarial mosquitoes. The campers cannot escape these insects, as they are the natural denizens of the watered rural districts; and they transmit to the new comers the malaria which they acquired from the previous campers. In so doing they are simply obeying the inexorable laws of their Creator, who has seen fit to construct their baneful little bodies for just this purpose—the perpetuation of another form of life.

From this it would seem that, if we must obey our primitive instincts to enjoy ourselves, and in our "love of Nature, hold communion with her visible forms," and "go forth under the open skies," it would be best to pattern our ideas of "Safety First," from that notoriously crafty and suspicious bird, the crow, in the fable so well known in Latin-American countries: "An old crow and a young crow were perched on the uppermost limbs of a dry tree along the roadside, the old crow with his head in one direction, the young crow with his head in the opposite direction. The young crow, seeing a pedestrian coming in their direction, but quite some distance away, said to the old crow: 'There is a man coming up the road toward us; and if I see him stoop, we'll fly away.' The old crow without as much as turning around to see, said: 'No, we'll fly now, he might have a rock in his hand.' "

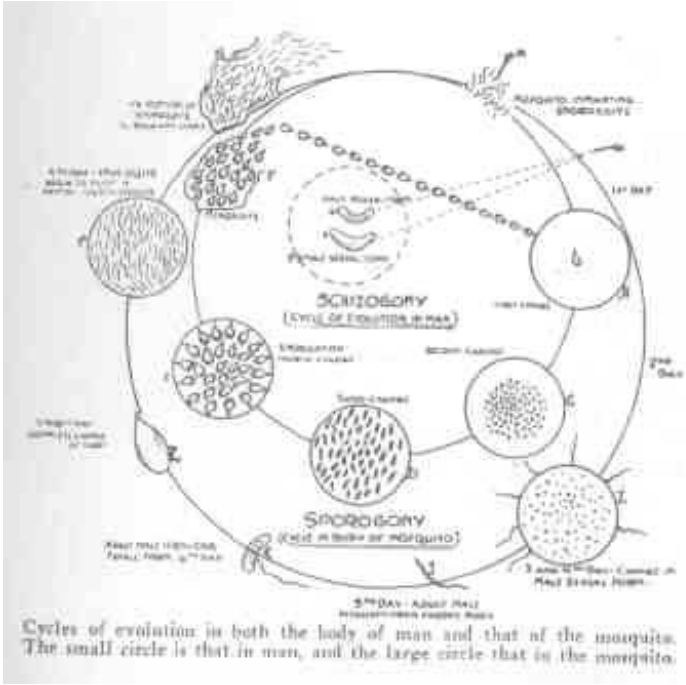
PHAGOCYTES POOR DEFENDERS

Figure 1 is a drawing of the white corpuscles, leucocytes, or phagocytes. They are the real defenders of the body, and are found in the blood in about the proportion of one phagocyte to seven hundred and fifty red corpuscles. Their functions could be likened unto those of the police force of a city, as they wander aimlessly about in the circulation until called for duty.

For instance, say one receives a cut or a wound of any kind. Information of such injury is immediately imparted to the brain, and the phagocytes in large numbers find their way to the

wound, which they surround in columns with almost military precision, ready to attack whatever bacteria might have been on the implement that produced the breach of continuity, or on the skin and introduced into the wound. ' They throw out one, two, or three finger-like projections; and the bacteria stick to the phagocytes like flies to sticky fly-paper. It may be, however, that the bacteria are of such a poisonous nature that they kill the phagocyte, but that is of little moment, as there are columns after columns behind one another, so that if those at the immediate front succumb, the next column takes their place, and so on until the bacteria are destroyed.

Leucosytes or Phagoctes. The police of the body.



Cycles of evolution in both the body of man and that of the mosquito. The small circle is that in man, and the large circle that in the mosquito.

Now, very much like after a fight between our peace officers and a number of bad men, the dead on both sides must be removed, so when we look at a wound and see it festering, the matter which we perceive is largely the dead bodies of the phagocytes and the invading bacteria, the latter having been killed by the former, who in turn also died like valiant soldiers in line of duty. Of course, the wound should now be opened, or it will open of its own accord,and soon rid itself of harmful material. Columns of phagocytes will still be on guard in the surrounding healthy tissue until the wound heals, and until their services are no longer required, when they will again return to and wander aimlessly about in the blood-stream, awaiting another call.

However, it sometimes happens that the phagocytes lose the fight and the invading bacteria are victorious and not held within the small area of the wound, but enter the blood-stream and cause the familiar condition known as blood-poisoning. Such instances occur in the bodies of people who are "run down," or in general bad health, due to disease, debauchery, or poverty. In these cases the defending phagocytes are weakened, smaller, and much lessened in number from the normal; therefore they do not have the defending or fighting qualities Nature intended them to possess ; and the invaders, not being arrested, overwhelm the body.

In malaria there is a constant battle going on between the phagocyte and the malarial parasite, but the phagocyte is very much at a disadvantage, in that it can attack the parasite only after it has ruptured the corpuscle (see Figure E); and countless millions of the parasites are thrown into the blood-stream, until each parasite again penetrates a corpuscle to continue the cycle of schizogony. After it has penetrated the corpuscle, the parasite is perfectly safe, as the phagocyte will not tear the

corpuscle to reach it.

NATURE'S CONSISTENCY

From this we perceive that Nature, who has given us this wonderful avenue for protection from these minute, invisible, but relentless foes, the bacteria, actually limits the protection of this particular parasite and allows it to thrive in the red corpuscle of man, which she intended to be its normal habitat. Astounding? Yes, but this assertion is

made advisedly; just as much as the Polar regions are the home of the Polar bear, or a cave in the wilderness is the home of the wolf or bat, or a hollow tree is the home of the squirrel, just that much is the red corpuscle of man the normal habitat of the malarial parasite; and, as said in the preface of this book, it is man and his kind only that carry this parasite. None of the domestic or wild animals carry it; it is distinctly parasitic to man. Cruel, the reader would think? Yes, but he must consider that there is no such thing as emotion associated with the works or so-called "mysteries" of Nature.

As a striking example of the cruelty and kindness, as we would view it, of Old Dame Nature, permit me to cite you the case of that large species of the spider family known as the tarantula. An insignificant little wasp pierces with its sting the motor centers of the spider, and completely paralyzes it, as far as motion is concerned. After it has overcome its struggles following the sting, it remains perfectly quiet, afflicted by locomotor ataxia, as in man. It is then that the wasp pierces its large abdomen and lays its eggs, which in the course of time develop into the larvae and adult wasps. If the wasp, by its sting, should destroy both the motor and sensory centers, it would kill the tarantula, and the hot sun would soon dry it up, so that it would not afford food for the baby wasps. What guides the delicate little lance to the motor centers of the tarantula? Here we see extreme cruelty in the tarantula being slowly consumed alive for the perpetuation of another form of life, and extreme kindness in providing such a magnificent abode and abundance of food for the baby wasps.

Thousands upon thousands of cases of tuberculosis are cured by Nature, as is evidenced by post-mortem examinations. Thousands upon thousands of cases of pneumonia, typhoid fever, scarlet fever, measles, smallpox, and other microbic diseases are cured without the slightest medical intervention. Nature cures them. Does she cure malaria? The answer calls for another question. Does Nature defeat her own schemes? Is there any reason why Nature should favor us? Our bodies belong to Nature, our souls belong to God.

ANALAGOUS PARASITES

As we are discussing in a cold, dispassionate manner one of Nature's lowliest of beings and its most intimate association

with her greatest of architectural triumphs, let us leave the works of the master minds, swivel chair, roll-top desk, and microscope, and again "go forth under the open skies," and we shall witness a striking analogue of parasitism in the vegetable kingdom.

A little plant, the familiar mistletoe, played a conspicuous part in mythology among the Norsemen and the Druids, for whom it had not only curative but also magical powers, attributes still surviving in modified form in our Yuletide custom of kissing under the mistletoe.

Doubtless there are other parasitic plants that play the same role as does the mistletoe and present identical analogies; but the mistletoe is so familiar and can be observed with so much ease, that we shall use that parasitic plant for our analogy.

The mistletoe does not thrive on all trees, any more than the malarial parasite thrives on all mammals; some trees seem to be immune to the parasitic mistletoe, just as all creatures in the animal kingdom, except man, are immune to the malarial parasite.

Let us select some particular specimen of the deciduous trees which is infected by this vegetable parasite, choosing, say, a hackberry tree for observation. The tree may have two or three clusters of mistletoe, which are readily visible in autumn and winter on account of the absence of leaves. Year after year the clusters will increase until it has quite a number; but, judging from the green leaves, little flowers, and berries which it brings forth in such profusion, and from the beautiful shade it affords, year in and year out, like the Master of the Animal Kingdom infected with malaria, it "appears to suffer no inconvience from harboring the parasite."

If we continue the observation over a period of years, we shall see at first a few of the uppermost limbs begin to wither, indicating a lost resistance. Like its deristant, infected human contemporary who becomes a prey to any of the disease-producing bacteria on account of such lowered resistance, due to the biological activities of the malarial parasite, the trunk of the tree soon affords the proper environment for the existence and multiplication of boring insects; and the parasitic mistletoe is gradually starved to death by its expiring host, for whose untimely destruction it is the direct cause.

As the malarial parasite has its normal habitat in the human red corpuscle and finds therein its nourishment, so the mistletoe resides on the hackberry, but it does not penetrate the woody part of the tree. When the seed finds lodgment, it spreads its growth into the bark only; and, although its texture is radically different from that of the bark of the tree, it merges its own bark into that of its host.

So perfect Is this natural grafting that the lines of demarcation are almost obliterated by the growth. In fact it becomes a part of the tree, and derives its nourishment from it,

just as do any of its own limbs or branches. But the part it plays never allows the tree to reach such a ripe old age as to permit it to be called a "Monarch of the Arboreal World."

The author has been observing this parasitic plant for a period of over twenty years, and in all that time has never seen it wither and die—evidently it is very resistant to disease. A dead cluster, however, is sometimes observed, but this condition has been occasioned by its being mechanically injured in a storm, or by a bird nesting in its clusters.

One of the high-class magazines sometime ago contained a description of brilliant experiments on plant life by a European scientist, who sought to demonstrate that plants had all manner of feeling, in fact, nerves. Should this prove true, what an added amount of suffering Nature has inflicted on the mundane life which she governs with such a ruthless hand! If the tree could speak, would it not cry out to the weary traveller who seeks shelter under its cooling shade from the sun's fiery rays? Would it not appeal to its feathered contemporaries who seek its branches for a trysting place, and so lovingly and laboriously make a home for the dear little hearts to come, to rid it of this merciless barbarian ?

And even Aeolus, as if to pity it for its fate, sends the sweetest of its messengers, the gentle summer zephyrs, which, as they pass by, convert the delicate withered branches of its crest into an aeolian harp, the harmony of which sounds one continual dirge, constantly reminding it of that majestic force, Nature—the force of all forces from which nothing can be expected that might have the slightest semblance of pity, tenderness, or mercy, and which knows nothing of these gentle virtues.

Another striking analogue of malaria in the human is seen in a parasite which finds its normal habitat in the red corpuscles of cattle, and causes a disease known to the cattle industry as the "tick fever," and sometimes as "malaria in cattle." This will be dwelt upon hereinafter when treating concerning the "Functions of the Spleen."

A person bitten by an infected mosquito today is infected; if bitten 25 or 30 years ago, that person has been infected and a carrier that long, at times exhibiting very obscure manifestations of the cycle of evolution, which he attributes to any but the correct cause.

As the general trend of opinion seems to be that all real knowledge must have a European origin, I quote Mons. Jules Carles, the eminent practitioner of Bordeaux, on the "Treatment of Malaria":—"insists that malaria belongs in the same class with syphilis—as a disease eminently chronic, with frequent revivals of manifestations and requiring treatment over years as with syphilis." The reader will note that this eminent physician does not give it as his opinion, but "insists' on his conviction as to the seriousness of malaria. This eminent gentleman's insistence on the seriousness of that disease requires no

endorsement, but the author is perhaps a little better qualified to add high approval than the average practitioner, as for years he has been limiting his practice entirely to two diseases, viz., malaria and typhoid fever—the former on account of its importance and extreme difficulty of eradication, and the latter because of malaria constituting with it a most formidable complication.

In the treatment of disease, the more the educated physician caters to old Dame Nature, the more certain is his reward in curing his patients; but in malaria he has a physio-pathological condition to deal with, as he is endeavoring to expel one of her own creatures from the home she intended it to occupy.

KNOWLEDGE AND APPRECIATION

It is the most ardent wish of the author that the information contained in this FIRST ALLEGATION will find its way to the Commissioners or Executives of the Councils of the Boy Scouts of America, as he feels certain that they would be more than glad to have it, if they but knew of its import and existence. It is these good men who give their time, money, and service to the betterment of the embryonic manhood of our nation; it is they who not only make manly little men out of ordinary boys and eradicate the "sissy" from the pampered ones, but also inculcate in them ideas

that will make of them future citizens of such quality as will insure the perpetuation of this glorious Nation. But the most essential quality to good citizenship is health; and taking the boys out on a hike to camp on the banks of some creek or mountain stream with no protection against mosquitoes, means the impairing of the highest and best directed efforts of these good men, by undermining the health of their cherished wards.

In 1905, the Greek Anti-Malarial League, a society composed of prominent physicians and laymen of Athens, Greece, came into being; and they have performed a stupendous work in the interest of their countrymen. As a demonstration of the colossal damage sustained by malaria, the society quotes thus the conclusion of certain highly-trained, scientific men who are giving most valuable time to their particular disease:

"The evil consequences are seen in the following ways:

(a) The most malarious districts also are the most fertile.

(b) The loss of time and money is very great.

(c) The effect upon the rising generation is most disastrous.

(d) The victims of malarial cachexia are weakened in body and mind.

(e) The inhabitants of malarious districts age rapidly and die prematurely."

The "Society for Improving the Condition of the Poor," having headquarters in New York City, says that illness causes 96 per cent of cases of poverty, and that only 4 per cent are due to drunkenness, old age, and non-employment. How much of this 96 per cent can be attributed to this world-wide disease?

It has been said that, "Public Health is purchasable," and this is indeed true, but the purveyors and purchasers of that "commodity" can drive good bargains only by directing their activities along self-illuminated avenues, and this self-illumination is KNOWLEDGE.

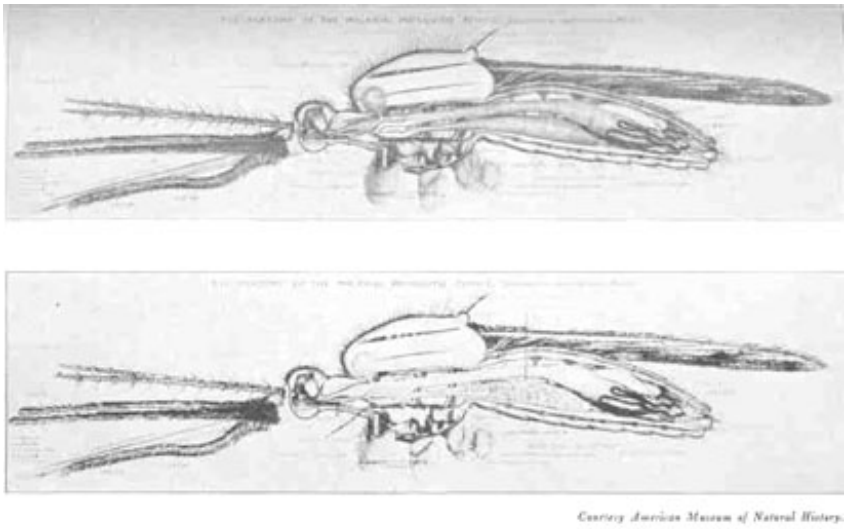
DESCRIBING SCHIZOGONY AND SPOROGONY

In studying any branch of science we are bound to learn words applicable to that branch, some of which are quite out of the ordinary; consequently, in studying the transmission of malaria, it is very desirable that we familiarize ourselves with the technical terms employed.

As man is as much a factor as the mosquito in perpetuating malaria, let us understand the role they both play. For the continuance of that parasitic form of life, we know that the parasites alternately occupy man and the mosquito. They are continuously undergoing a cycle of evolution or metamorphosis, something on the order of the cycle of evolution of the butterfly from the egg to the cocoon, though infinitely more complex. The cycle of evolution occurring in the body of man, is termed Schizogony, (see Figure 2, small circle) and the cycle of evolution in the body of the mosquito is termed Sporogony (see Figure 2, large circle).

The fine needle-like bodies which the mosquito pours into the circulation of man in the act of biting, are called sporozoits (see Figure A), "Mosquito-implanting sporozoits." The word "sporolating" is equivalent to the word breeding or hatching. The word gammets means the male and female FORMS seen in the small circle on the inside of the large circle describing schizogony and marked H—G. The word, merozoit, is the name of that form of the parasite seen in Figure F.

Figure 2 shows the anatomy of an uninfected normal female mosquito. It might perhaps be well in passing to mention that the male mosquito does not bite; its sole function is that of procreation.



Courtesy American Museum of Natural History.

Figure 3 shows the anatomy of an infected mosquito; and the reader's attention is particularly directed to the underscored names of three structures: Ventral food reservoir, salivary gland, and salivary duct. The most important structures for study are the salivary glands, or, as they also might be called, saliva or spit-glands.

See long photo Figure 3. The photograph of the mosquito marked "normal" is a most remarkable piece of ceramic art, and was procured by the author from the owner, the American Museum of Natural History of New York City. The picture marked "infected" is a copy of the same photograph which the author "infected," showing the second-last and final change of the cycle of evolution that takes place in the body of that insect.

There is no more beautiful example of the truism that "Knowledge is Power," than the knowledge of these glands. They are but very little larger than a period made with an ordinary writing pen, yet an intimate knowledge of their functions and behavior made possible the completion of the world's greatest engineering feat, the Panama Canal. When the French attempted the building of the Canal, they had all the requisite equipment: brains, money, and tools,—but they failed on account of not knowing the functions and behavior of the salivary glands.

THE MOSQUITO'S BITE

These glands are given to the mosquito by Nature, principally to harmonize with one of her physical laws. Let us see how. If we had a hypodermic needle made of the length and diameter of a mosquito's proboscis, or stinging apparatus, and if we should attach it to a hypodermic syringe and insert it into the human skin, as does the mosquito with its hypodermic needle, then pull on the piston of the syringe as does the mosquito in the "act of sucking, we would get no blood in the barrel of the syringe; it would coagulate in the needle. Yet the blood in the mosquito's needle does not coagulate. "Why? Because it is a physical property of blood that it will not clot or coagulate in an alkaline medium. For illustration—if we had

two glasses half-filled with water, and in the one we dissolved a few grains of any alkaline substance —say, bicarbonate of soda —and in the other were left the plain water, and if we poured some fresh blood into each glass, it would be seen that the blood in the glass with the bicarbonate of soda, or alkaline water, would not coagulate, but that the blood in the glass with the plain water would do so.

Now, the mosquito, in the act of biting, inserts her bloodsucking apparatus into the skin to reach the blood underneath; but, before the process of sucking begins, she injects into the circulation a small complement of alkaline fluid from the salivary gland through the salivary duct, and so alkalinizes the small area of tissue from which she is going to draw blood; and thus her meal is insured by the non-clotting of the blood in that delicate needle, her proboscis.

As can be seen in Figure 4, (long photo Figure 4), "Infected Mosquito," the ventral food-reservoir is filled with the immature sporozoits in tiny globules; and those free in the salivary glands have ruptured the globules and found their way there. It is when the mosquito, in the act of biting, pours the alkaline fluid from the salivary gland through the salivary duct for the purpose already mentioned, that the sporozoits also are injected or implanted in the blood-stream; and then the individual bitten becomes infected, and the cycle of evolution known as schizogony begins.

Figure 2, Schizogony, the cycle of evolution in the body of man, at A shows an infected mosquito implanting the sporozoits. Each small round ring, through which passes the large circle, represents a red corpuscle. After the sporozoit has been injected by the mosquito, it immediately, for protection against the phagocytes, enters the red corpuscle, loses its identity as a needle-like body, and assumes the shape seen in B, C, and D, the second and third changes. At E, the fourth change, the contents of the corpuscle could be likened perhaps unto numerous little olives. This condition is known as the period of sporulation. The corpuscle now ruptures, as seen in F, and countless millions of the parasites known as merozoits are thrown into the blood-stream. Almost immediately, to escape again their enemies, the phagocytes, they re-enter a corpuscle, as in B, the cycle being completed, and are again ready to continue. As far as the individual infected is concerned, the infection can go on no further, but Nature, for the perpetuation of this form of life, evolves certain of the merozoits into the two boat- or bean-like bodies shown in the small circle within the large one, and marked G and H. These bodies are the male and the female forms of the parasite, and are destined for evolution in the body of the mosquito, the smaller, G, being the male, and the larger, H, being the female. These bodies are formed in great numbers after the completion of each cycle, and this takes place every 48 or 72 hours, and can continue for an indefinite number of years. The infected individual is referred to as a "gamete carrier;" and in making a malarial sanitary survey, a community is referred to as being more or less malarial according to the number of "carriers" found.

Figure 2 is a drawing taken from Dr. Graham E. Hen-son's splendid book "MALARIA," published by the C. V. Mosby Co., of St. Louis, Mo., although somewhat modified. The modification consists in showing in circles or rings the various changes on the part of the parasite in the body of man, and is intended to represent the red corpuscle, as all the different changes of phases of evolution occur inside of the said corpuscle. In a foot note explaining the drawing in Dr. Henson's book, he says: "There is no attempt in the foregoing to follow each and every stage of evolution that takes place in the circulation of man, or in the body of a mosquito, it being the aim simply to bring out the salient points that take place in the evolution of the parasite." This applies to the author's modified drawing; and again, to make the different stages of the cycle of evolution that takes place in the body of the mosquito more easily understood, a presumptive approximate age is given to each different phase.

MOSQUITO CYCLE OR SPOROGONY

The cycle of sporogony can and does take place only in the body of the mosquito. When the normal or uninfected mosquito bites a man, or better still, a "carrier," she engorges and then rests for a period of time during which she voids the liquid portion of the blood, in order to concentrate her food, digesting all the solid elements except the gametes, H and G. On the first and second day no perceptible change takes place on the part of the gametes, but on the third and fourth days the small gamete, or male form G, enlarges very much (see I in drawing), and throws out from two to eight of what might be likened unto long, thin tails. These detach themselves from the parent body and become the fully developed males (J). About the fifth day they are very active and in quest of the female; and about the sixth day they encounter and fertilize her (H), as seen in K. The female (H) now loses her identity as a bean or boat, evolves into form L on the seventh or eighth day, and is found very active in the muscular walls of the mosquito's Intestine. About the ninth day these bodies begin to evolve into form M, which are the sporozoits; and in another day or two the latter find their way into the ventral food-reservoir. As each little globule, containing hundreds of immature sporozoits, ruptures, the said sporozoits find their way into and become lodged in the salivary glands, to be injected again into the circulation of man, when the mosquito seeks another meal. This cycle requires from TEN to FIFTEEN days, averaging TWELVE, for its completion. If, however, this mosquito should bite a human before the cycle of evolution is complete, she would not infect him, as the cycle is not completed until the sporozoits are in the salivary gland. The reader is kindly asked to keep in mind the time required for this cycle of evolution to complete itself, as it has a very important bearing on the evidence concerning the eradication of malaria.

In comparing the two mosquito pictures, the infected and the non-infected, we see that the mosquito apparently does not mean to be the malignant insect it really is, as its ventral food-

reservoir is what its name implies, a reserve or storage for food to be called upon when needed. The salivary glands are to store the alkaline saliva so as to prevent the clotting of its food, the blood, in its delicate, bloodsucking apparatus, the proboscis; and the function of the salivary duct is to conduct the saliva to the blood under the skin. Hundreds of normal malarial mosquitos might bite us, and we would never acquire malaria, even if we lived in a notoriously malarial country.

The work of the demonstration of the two cycles of evolution we have just gone over is regarded as the most masterful piece of medical achievement, and has required for completion twenty-four years of the most painstaking labor on the part of the world's greatest minds.

Nature does not loudly proclaim her achievements or secrets, but she has endowed the highest of her creatures with that God-given function of REASON that he might unravel what appear as her mysteries and use her creatures to his advantage. While it may seem to some of us mysterious and highly perplexing that Nature should choose the body of her greatest architectural triumph, man, and the body of one of her lowliest of creatures, the malarial mosquito, each to take part independently in the evolution of a much lower form of life, she continues the mystery by providing for the destruction of that most malevolent of insects; and, as if to atone to man for the punishment she inflicts upon him, Nature endows her most wonderful creation, the bat, with such habits, and faculties as result in its being one of man's best friends.

THE CALL OF HUMANITY

This concludes the argument of the "First Allegation;" and it is hoped that there have been advanced such convincing arguments as will warrant the reader in deciding to use not only his personal influence, but also to enlist that of all his friends in spreading this knowledge; because it is only by the diffusion of such knowledge among the school children, our future citizens, and among the masses in general, that we can hope to eradicate the malarial mosquito, which has been shown to be one of the greatest enemies of mankind.

"One half of the world knows not how the other half lives." This hoary axiom might very properly be paraphrased into "One half of the world knows not how much the other half suffers;" and the reader must conclude that a large percentage of that suffering is the tribute Nature demands in the execution and continuance of her schemes. "What a magnificent opportunity awaits the immensely wealthy man who wants to do something really and radically novel and colossally grand in results! If the author could have a personal interview with such a gentleman, he would soon convince him of the fact that the eradication of this malevolent parasite would be the greatest philanthropic work that could possibly be undertaken, because it not only involves our own country, but also the entire world; also that by directing his energies to the one cause, and the one cause only,

the greatest of economic problems could be solved, and the creation of a superior nation accomplished, while he himself would be immortalized by handing down to his children and to posterity his fame as one of the world's greatest benefactors.

The preceding dissertation confirms Allegation One.

Allegation Two

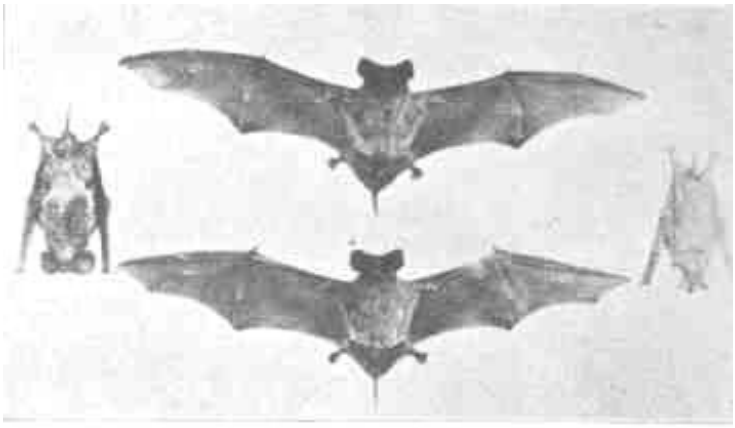
That the bat is one of man's best friends because it so relentlessly destroys the malarial mosquito, as that insect is its natural and principal food.

Conditions and Habitat of Bats

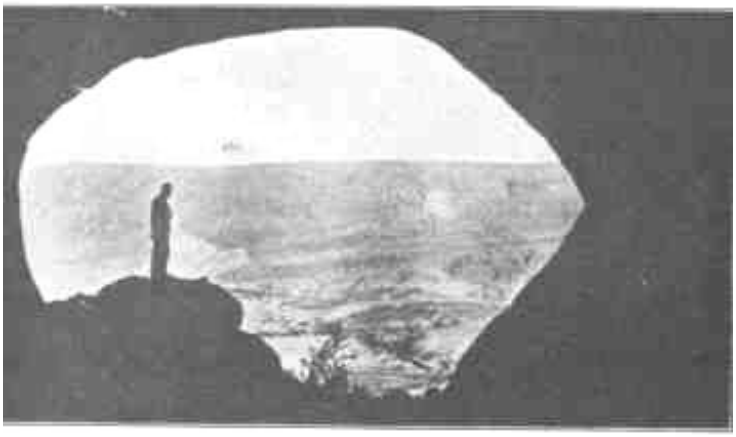
Bats are found all over the world. There are more than two thousand different varieties, classed as the oldest of mammals, and, geologically considered, going back millions of years. As the larger species, or fruit-eating bats, are of no concern for our purpose, we shall consider only the small and beneficent species of bats which are gregarious, or live in colonies, and only resemble, but are not kindred to, the malevolent vampire bats of South America, or the fruit-eating bats of the tropics.

The bat gets its scientific name principally on account of its nocturnal habits; the zoological name of the species most common, being Nyctinomus Mexicanus, the word "nyctinomus" meaning "night mouse." In different countries they are referred to by different names, among them being "heaven mice," "sky mice" and "winged mice;" but the French have a most peculiar designation in "Bald Mouse," for certainly the bat is anything but bald, though its wings are.

There are very few, or none, of Nature's creatures that offer more anomalies and present more difficulties for study. It is distinctly a mammal, and usually brings forth one or two young annually.



Bats, Male and Female.



Brewster County Cave.
An abandoned bat home, from which 26 carloads of guano were taken out.

Uvalde Cave. Bats emerging towards evening.

Top: Bats. Male and Female. Middle: Brewster Couinty Cave. An abandoned bat home, from which 26 carloads of guano were taken out. Bottom: Uvalde Cave. Bats emerging towards evening.

To the average laymen, particularly the ladies, if the adjectives gruesome, repulsive, and repellant were added to those employed by Mr. Edgar Alien Poe in his "Raven," grim, ungainly, ghastly, gaunt, and ominous, they would just fit their ideas of the bat's personal appearance. But, notwithstanding all this, to them in particular is the bat a most valued friend.

If the ladies of any community were told that there was a natural agency existing among them that actually ruined that most desirable of charms, a beautiful complexion, and if to destroy this natural agency they were asked to raise a large

fund, it goes without saying, that the said fund would be over-subscribed. Nothing is so common a cause of the destruction of a beautiful complexion as the malarial parasite which the malarial mosquito implants directly in the blood-stream, and which liberates, during its existence in the blood, a deep brown coloring matter, known as melanin. This pigment or coloring matter, which is insoluble, deposits itself under the corium or true skin; and then a dirty, yellowish, sallow shade takes the place of the school-girl complexion.

It seems that Nature in evolving the bat tried to build as nondescript a creature as she knew how, throwing in a little of this and a little of that, to see what would result; but when we study its anatomy, we see that Old Dame Nature, rearing her creatures with her illimitable and inimitable faultlessness, has made no mistakes, when she created this animal for the purpose she intended it. It is not a bird, yet it has some of the anatomy of birds. It has no feathers, yet can put many a bird to shame in flight. It is nocturnal, yet has very small eyes in contradistinction to birds and other creatures that must find their food at night.

Its normal habitats are caves, caverns, and sometimes abandoned mines or quarries; and some of these it occupies by the millions. There are, however, a great many caves in the wilderness, some of which look as much alike as two peas, yet the one will be inhabited by millions of bats, and in the other not a single bat is to be found. In other caves, a layer of very, very old guano one or two inches in depth with not a single bat in the cave, gives conclusive testimony to the fact that for a short time bats were inhabiting it, but conditions and environments to their liking were not there, so they did not remain. There are hundreds of caves that, for these very reasons, are not inhabited by bats, notwithstanding that they have been in existence "since first the flight of years began." We shall have occasion to revert to this feature of a bat cave when we reach the THIRD ALLEGATION. In the State of San Luis Potosi, Mexico, is to be found a very, very old mine, that was worked by the earliest Spaniards, and abandoned on account of the ore giving out. This old mine, several hundred feet in depth, with its many tunnels aggregating miles in length, became inhabited by these creatures; and, as it was not emptied nor worked for commercial purposes, in the course of time it became entirely filled with guano, so much so as to shut out the bats themselves.

Going into a bat cave is very much like going into an ice factory in which an ammonia pipe has burst. The extreme darkness, the ammonical gases generated in the caves by the decomposing guano, which almost robs the air of sufficient oxygen to sustain life, a pair of glistening green eyes of some wild animal, with the occasional biz-z-z-z of a rattlesnake's frightful warning, and wading in one or two feet of soft guano constitute the environment in which the student of bats finds himself; and such conditions are not in the least calculated to stimulate his enthusiasm for scientific research.

It is astonishing on what a small amount of oxygen these mammals can thrive, when we consider that they have the lung capacity for remaining on the wing in continuous flight for ten or twelve hours. They hang to the roof of the cave by the millions, touching one another, and even hanging on one another in huge bunches which resemble swarms of bees; and how those in the center of these bunches keep from suffocating is simply inexplicable.

Cibolo Cave. Bats emerging towards evening.

Bats in myriads clinging to the ceiling of a cave, their normal home. Cibolo Cave.

Uvalde Cave. Another natural Texas home of bats.

Top: Cibola Cave. Bats emerging towards evening. Middle: Bats in myriads clinging to the ceiling of a cave, their normal home. Cibola Cave. Bottom: Uvalde Cave. Another natural Texas home of bats.

There is no cave inhabited by bats, whether worked for

commercial purposes or not, that in some remote time had not been on fire, as evidenced by the entire floor being covered by compacted ashes, sometimes fifteen feet thick. This occurs only in caves that are not worked, and in which the guano is allowed to accumulate, and into which rain finds its way. The fires are brought about by chemical combustion from the heat generated by the decomposing guano, which is eventually largely converted into nitrates and nitrites, or saltpeter. A cave on fire in the mountains at night is indeed a rare sight, as the reflection coming from that seething furnace is no larger than the opening, which is sometimes but a few feet in diameter. If the opening is on the side of the mountain, the darkness all around it, the intense stillness and solitude, with the tips of a few trees silhouetted, give it the weird appearance of a cyclopean eye. The bat caves on fire are referred to by ranchmen in the vicinities as "smoke holes." As it is these caves that furnish the bats with the conditions and environments to their liking, they return to them when the fire dies out and the cave has cooled off, which sometimes takes many months.

Regular HAbits and Movements of Bat Colonies

Besides the most wonderful instinct of orientation that bats have, and which will be described later on, they possess also to an eminent degree that of migration. It is this instinct of migration that we can take advantage of and cause to render us its great hygienic and economic benefits. Observations in the well-tenanted caves verify this instinct, as millions of bats leave the caves with the coming of spring and summer, and return with the advent of autumn and winter. This is well known to people who own bat caves and work them for commercial purposes. Several years ago, and again last year, it was the good fortune of the author to see a swarm of bats at least one mile wide and six miles long, travelling in a northeasterly direction. A prominent fisherman on the east coast of Florida related to the author how he had often seen bats flying over the Florida Keys in such numbers as to throw a cloud or shadow on the water. He has a fleet of fishing boats, and both he and his men have seen them flying *all day long* in one huge mass. They were migrating from the south, going north, seeking their food.

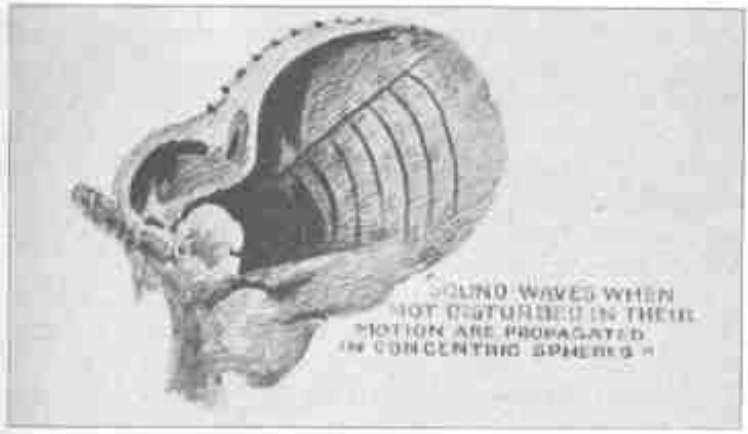
Normal Position for Repose

The normal position of bats in repose is hanging head downward by their short hind feet, which resemble tiny hands and are provided with very sharp-pointed, curved, rigid claws. These it can spread out, but the angle of curvature remains, so that when it hangs, no muscles are brought into action, hence volition plays no part; and their claws, once finding a place to hook to, insure perfect hanging with all free body movements, such as scratching itself, love-making, etc. Often it will loosen its hold of one foot and employ it in scratching the back of its neck to rid it of some troublesome parasite, while hanging on with the other foot.

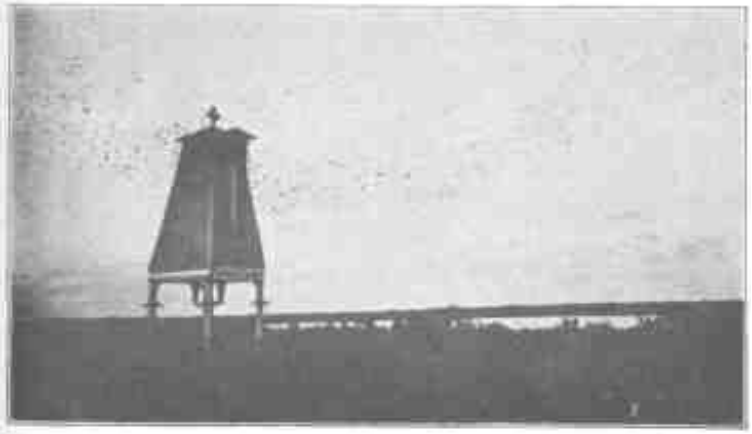
After death bats are still found in the hanging position. An idea of the fineness of their claws can be had when we examine an ordinary piece of rough 2x4 inch lumber rendered as smooth as if sand-papered by hand, on which these little mammals had been roosting for a number of years. When crawling along on a horizontal surface, they depend more on the hook-like apparatus at the thumb joint on their wings for propulsion than on the hind legs, though these assist somewhat, but in a very awkward way, being spread out in a manner similar to that of the toes on a horned-toad's hind legs.

On flying to their perches where they roost, in old barns and abandoned houses, during the feeding season, they sometimes make several unsuccessful attempts to land in their roosting places, one attempt following the other; this is due to their failure in securing the preliminary hold with the flexible hook at the thumb; but once off the wing, they immediately bring their hanging position into use.

Bats in old barn. This is seen only in mid-summer and sometimes hundreds of miles from their normal homes.



Bat's Ear, enlarged.



Bats emerging from Mitchell's Lake Bat Roost.

Top: bats in old barn. This is seen only in mid-summer and sometimes hundreds of miles from their normal homes. Middle: Bat's Ear, enlarged. bottom: Bats emerging from Mitchell's Lake Bat Roost.

The ungainly, froglike angle of their hind legs fulfills two distinct purposes. As the legs are inserted in the folds of its web, this brings that portion of the flying apparatus in control of the legs, permitting them to act as a rudder that can be extended or contracted at will. When the bat is in repose, one can readily see how perfectly the legs are situated in relation to the centre of gravity.

THE BAT'S SUPER-ACUTE SENSES

As far as the author has been able to ascertain, the bat is the only animal that hunts its food through the sense of hearing, although it will follow a large moth around an electric light for a few seconds, as if employing both sight and smell, before devouring it. A great many nocturnal insects are provided by Nature with acrid or even blistering fluids for their protection, and how the bat in its rapid flight avoids these insects is, the writer believes, accounted for by the fact that it will attack only such insects as emit certain tones in their flight; and it is through the tones so made by the vibrations of the insect's wings that the bat distinguishes the species best suited for its food. As a result of many observations along these lines, the author has found that insects emitting a tone lower than C natural, first ledger line below the staff (International pitch 440), are avoided by bats. The tones emitted by mosquitoes range from staff D, to F, G, and even higher.

The afore-mentioned observations were made under an electric arc-light around which hovered innumerable insects attracted by the glare, as well as a number of bats attracted by the presence of the smaller winged creatures. With an insect net the author caught a number of these insects which, it had been previously observed, the bats were rejecting; also a large number of mosquitoes and other insects of the species which the bats were devouring.

In the case of the rejected insects, on causing them to fly in the net the tones emitted were invariably lower than C natural; while for the accepted insects, which, by a large per cent, were mosquitoes, the tone ranged from C sharp (staff) to F or G. The sudden dips, dashes, and dives the bat makes through space also support this observation; for these quick dashes, due to objects entirely out of its range of vision, could only be induced by its hearing some favorite insect in that locality.

Another convincing proof of this assertion, and one which is in entire accordance with the foregoing, is that the flight of the bat is noiseless. The accompanying enlarged photograph of a bat's ear shows the anatomy of that organ to correspond with our knowledge of the physics of sound; because the cartilaginous concentric ridges correspond to the spherical soundwaves, while the cartilaginous, conical projections placed on the edge of the ear are to break these sound waves, should they pass above the said cartilaginous ridges.

THE BAT'S HAIR

The hair covering any animal's body serves it as a protection against the vicissitudes of the different seasons, as is evidenced by the fact that it sheds the light coats of Spring and Summer, and acquires a dense and heavy coat during the Autumn and Winter. Hair is generally cylindrical in cross-section ; usually it is straight, and although it might be curved or even curly, it will still retain its round shape. Again, it might be either highly

or lightly colored, but still retaining the characteristics peculiar to the animal it covers.

With the bat's hair it is entirely different, as will be seen in the picture marked "Bat's Hair Highly Magnified." There we see three different and distinct sorts of hair, and a radical departure from the form of the ordinary kind. This peculiar hair covers its entire body, and is not confined to any particular or selected place. All through the aeons of time the hair covering a bat's body has undergone no change. Unlike most mammals, the bat does not shed its hair, as Nature has converted its body into a vital radio, the hairs serving in a most admirable manner as antennae for capturing the different sound waves emitted by mosquitoes and other small insects in their flight, thereby enabling the bat to catch them.

BAT'S HAIR. HIGHLY MAGNIFIED. NOTE THREE DISTINCT TYPES.

Ordinarily-round wire serves the artificial radio quite well, but in the bat's hairs we see the construction of natural antennae intended to capture sound waves, and we also see three different kinds of construction which ordinary reasoning tells

us is for capturing sound waves of different characteristics, regardless of the number of vibrations per second of time. All of this peculiar and extraordinary hair-formation, in addition to the wonderful anatomy of the bat's ear, is destined by Nature for the procurement of the animal's food; and as it was that infallible Old Dame who made sound waves, surely no one more competent than she could have constructed a food-procuring device to serve in the perpetuation of a species to endure through unknown millions of years.

But this most remarkable and peculiar hair not only serves the bat as a means of procuring its food, but it also protects the animal against its natural and principal food, the malarial mosquito. It is a well known fact that the female mosquito cannot oviposit, or better said, her eggs will not ripen in her body without albuminous or animal food; and, in obedience to the inexorable laws of Nature, this insect might possibly transmit to the animal the diseases she sometimes carries. As matters stand, it is the dense hair with its innumerable lances and pockets which prevent the mosquito's proboscis from reaching the bat's skin.

TESTING BATS' HEARING

That Nature always gives a creature protection from its enemies in some form or another is a matter of common knowledge. Accordingly, if the bat is the arch enemy of the mosquito, surely this insect must have some method of protecting itself against that creature. Just what form of protection the mosquito resorts to is readily reasoned out; the mosquito must stop its flight to protect itself, for it is by the vibrations of its wings that the characteristic sound waves are produced, attracting the bat's attention. In order to prove this line of thought, the author made an experiment which places this point out of theory and into fact.

A small room, 10 feet long, 5 feet wide, and 5½ feet high, was thoroughly cleaned, canvassed, and white-washed. The room had one small window to the east and a door to the west, both of which were thoroughly screened with fine wire mesh. Tens of thousands of mosquito eggs were procured and placed in a tub of cistern water, to which there was previously added some organic matter to furnish food for the larvae. In the course of time thousands of mosquitoes hatched out. and these were fed by placing two turkeys and two old fat hens in the room until all the mosquitoes were hatched.

At night, after the mosquitoes had developed into adult insects, their buzzing noise could be plainly heard several feet from the room. On one occasion the writer entered the room with a darkened electric flash light and liberated two bats. Instantly the buzzing noise ceased, and on turning on the light it was observed that the mosquitoes were clinging to the walls and perfectly motionless. On taking the bats out of the room, in less than three minutes the buzzing noise was resumed. This experiment was afterwards repeated several times with the

same results.

Some few days after making the above experiment, the author had occasion to go to the Mitchell's Lake lands, as he had done every Friday for years, devoting that day of the week, during the spring and summer, to the exclusive study of bats. He was met by one of the lowly peasants who was a great admirer of the bat roost and the study that was being conducted on those lands. He asked the author if he recognized that the mosquitoes actually know how to defend themselves from the bats. After receiving a rather evasive answer, made with the object of drawing from him what might prove a valuable observation, or at least, perhaps, a clue to the habits of bats and mosquitoes that study might develop, he said he had watched mosquitoes and bats in his cabin for a few nights, on account of the interest he took in them, particularly in the destruction of the insects, and because of his desire to aid in the work. His own words tell the story best: "I have been noticing," said he, "how funny it was the buzzing noise of the thousands of mosquitoes in my cabin at night stopped * instantly when the bats came in. Oh, I tell you the mosquitoes are sure smart. One night, the mosquitoes were so bad, *(i. e.,* there were so many of them), that their singing noise was loud enough to bother my sleep. Of course I sleep under a mosquito bar, but wanting to watch these things for you, I had a good chance on account of the moon shining so bright; and in my house I could see the mosquitoes very plainly, so kept awake. The funny sing-song of the mosquitoes was one and the same tune, until a gang of bats came into the cabin. Right away the tune shut off, all you could hear was the bats' wings hitting against one another, and another little noise of which I don't know the cause—but it was no mosquito tune. When I saw the bats leave I got up out of my bed and lighted my lamp. There they were, hidden from the bats, and plenty of them right under my bed. Ain 't mosquitoes smart?″

The "noise" of which our peasant friend "did not know the cause" was produced by the rapidly-moving jaws of the bats in the characteristic munching of their prey. When they dive into a swarm of mosquitoes, this can easily be heard, as they must catch the insects with astounding rapidity, before the latter adopt the defense of closing their wings and dropping to the ground, grass, or wherever they may be. It is a very singular sight to see a swarm of mosquitoes so thick as to resemble a black mass of smoke suddenly vanish on the appearance of the bats.

It is a very common experience to see a bat enter a dwelling well lighted, and fly about the room, over, under, and between the most delicate of bric-a-brac, without as much *as* touching any of it. It did not enter seeking a home, as it never intended to remain, nor did it want any food belonging to the home owners, or even to do them the least harm imaginable. It entered seeking its own food; and, if left alone and unmolested, it will always leave as suddenly as it came, and with it, or better said, inside of it, will go all of the mosquitoes that were in the room. However, this rarely happens, as the entrance of a bat into a

room or dwellings brings about consternation ; and every occupant will seek the nearest umbrella, broom, or what not, to swat the little sanitary messenger who entered on its beneficent mission, only to be rewarded with pain and death, and that at the hands of the highest of beings, to whom he is such a friend.

Nature having so admirably protected the bat from the bite of the mosquito, she carries her protection to greater depths by adapting one of its internal organs to the character of the food she intended for its nutrition. It is from this internal organ that we get some startling and affirmative information which constitutes one of the strongest points in the demonstration of the fact that the malarial mosquito is the natural and principal food of the bat. However, a little serious reflection would lead us to think, and rightfully conclude, that when Nature intended the blood in the mosquito's body to be vitiated by one of her own creatures so as to become wholesome food for the bat, she also made some provision for that vitiated blood to become wholesome for that creature, just as she provided for the putrid flesh of a dead animal to become wholesome food for a buzzard. The internal organ referred to is its spleen, a detailed study of which will be found hereinafter under the head of "FUNCTIONS OF THE SPLEEN."

THE BAT AN INTELLIGENT HUNTER

The author had a friend who, becoming deeply interested in the bat as a destroyer of mosquitoes, paid him periodical visits with the object of enquiring as to new experiments or developments in the bat work. He became quite an enthusiast, ever pleading with the author to continue the work, and offering words of the highest praise as encouragement,

One morning he came to the author's office, his face beaming with radiant smiles, and said: " I have something that to the average man would mean but little, but knowing you as I do, to you it is the grandest treat of your life." It really proved a treat of the highest order. He occupied a room on the third floor of a hotel in the central business district; and it happened that this building was not provided with wire screens. Across the street from his room is a large department store. One morning he awakened about five o'clock; and, in thinking about his business affairs, his sleep left him, then he turned his face toward the open window, gazing aimlessly into the empyrean. It was not long before he saw the "treat," in fact, quite a number of them, which aroused such enthusiasm in him that he forget not only his sleep but his business affairs as well.

The next morning at 4.30 o'clock the author found himself with his friend in the latter's room sitting on the carpet before the open window, looking at the gradually approaching dawn. It was not long before a bat flew by, then another and another. On looking out of the window, the author counted the bats, to make the observation more correct. There were just four bats flying backwards and forwards on the hotel side of the street. Presently we saw an engorged mosquito flying slowly out of

the window, being burdened with an abdomen full of blood. It had not gone three feet from the wall, when a bat got it in plain sight of both of us. "Ain't that great? That's the treat," shouted the friend, adding emphasis to his enthusiasm with a hard slap on the back, and some more words of encouragement.

But the author was almost without feeling or hearing, even speechless, not at the sight of one engorged mosquito being waylaid by the bats, but at seeing every one that left the room captured with the most dextrous facility and unerring certainty. Not a single mosquito escaped our eager eyes, neither did it escape the keen ears of the noiselessly-flying, acrobatic sentinels on the outside of the room. Sometimes the bat in its flight would be as much as two feet above the flying mosquito, but on approaching it and getting the sound of its wings, would instantly arrest its flight, turning what appeared to be a complete somersault, but righting itself almost in the same instant. When flying below the emerging mosquito, it seemed to have the facility of gyrating upwards, the movement being executed with incredible rapidity; again, it appeared to approach the mosquito at an angle, as if volplaning. However, whether gyrating, somersaulting, volplaning, or whatsoever manner of flight or complex aerial movements the bat employed, the fact remains that it got the mosquitoes, and we SAW it in the act of catching them.

The reader can well imagine the emotions aroused in the author at this sight, and the frenzied ecstasy of witnessing with the eye the creature he had so intensely and laboriously studied in his endeavors to find the evidence he believed would entitle it to an exalted place in the domain of hygiene, exhibiting its true nobility and making its own evidence—and that evidence of such an uncontradictory character as will permit it to pass through the molecular meshes of scientific scrutiny.

As the mentioned screenless hotel is only one block from the author's office, it made observations of the bats there very convenient indeed. At no time, whether in the spring, summer, or late fall, were the bats ever observed parading in front of the hotel windows in the evening. They were to be seen only in the very early morning, and at no time in front of the windows of the large department store across the narrow street. The reason is quite patent; on that side of the street there was no food, neither was there any food on the hotel side until early in the morning, when the engorged female mosquitoes left the room to seek the male and water.

NATURE'S PHYSICAL ECONOMICS

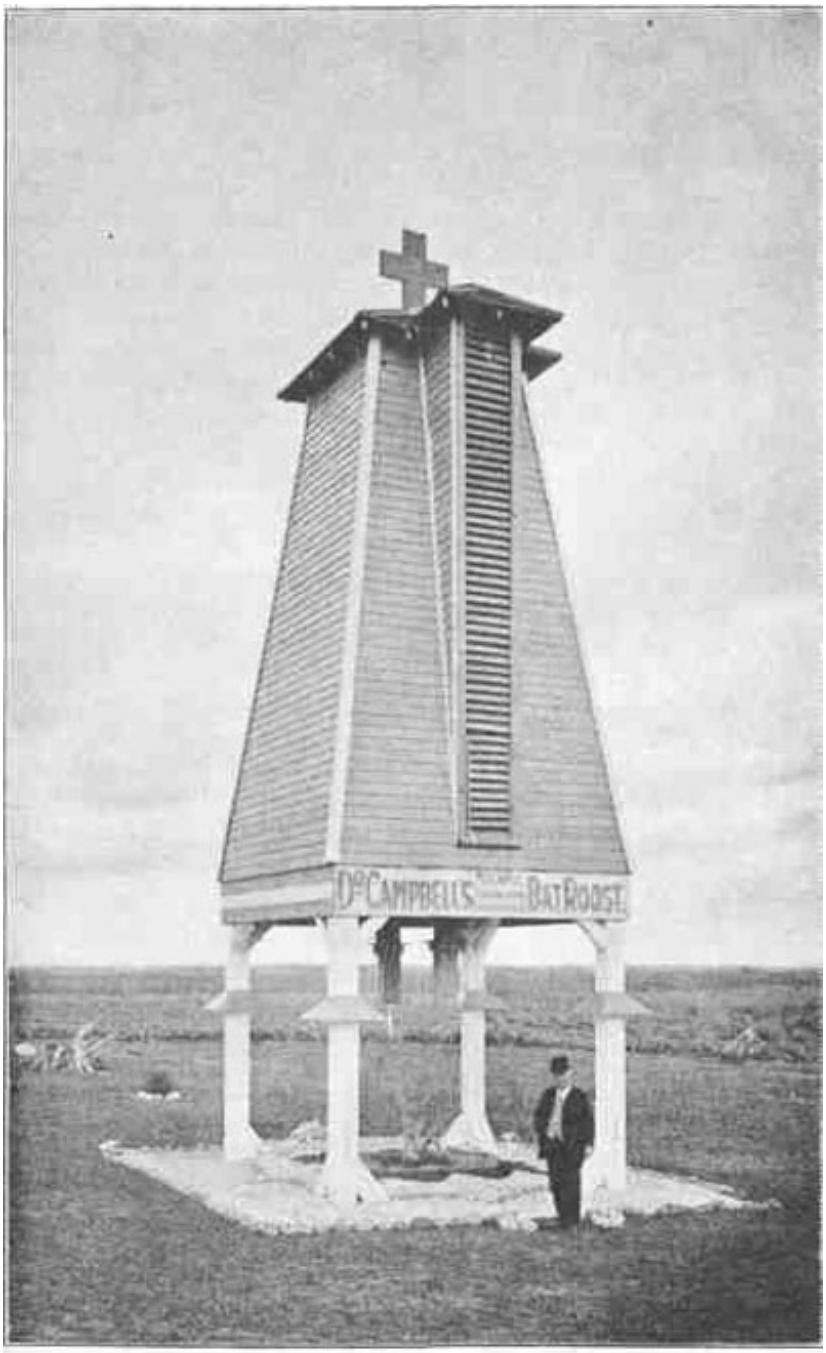
Bats are conserved by going into a state of suspended animation, or hibernation, in the place where they roost for the winter. They can be heard screeching and moving about on warm days; but after a cold snap they can be handled like so many dead sparrows, tossed and thrown about, apparently lifeless. A rare heartbeat can be distinguished, but no diaphragmatic breathing; and their bodies are as cold as the

surrounding temperature. A temperature of 25 degrees below zero does not seem to disturb them at all; for they are found in Vermont in caves where the temperature falls that low in the winter months. When caught in the winter and placed in a warm room they soon revive and fly about—just as in midsummer. Nature has so beautifully balanced their winter rations that flying about in a warm room calls for energy, and that energy for food, so that they consume the food intended to tide them over the winter, and consequently die within a day or two.

This has been the oft-repeated experience of the author in handling and studying bats in the winter time; but, as everything about a bat seems to be reversed, they can be observed exercising in mid-winter after a little warm spell. In several buildings where bats find lodgment, they can be seen flying backwards and forwards on the outside at a great velocity, but for only a few minutes. This would lead one to conclude that they have the remarkable property of drawing on their fat for food at will. The rapid flying could be nothing other than exercise, as in mid-winter in this climate there are no mosquitoes or other insects they might be seeking.

They accumulate quite an amount of thoracic and abdominal fat, as was evidenced by post-mortem examinations made during the month of November. The average weight of the free-tail bat about the middle of February, when its period of hibernation is at an end, is about two drachms and five grains, or a trifle more than one-quarter of an ounce; and towards the middle of the month of November, when its feeding season is about to close, its weight is about three drachms and forty grains, or nearly one-half ounce. They are particularly active after the month of July, as it is from then until the feeding season closes that they must accumulate the necessary fat to tide them over the winter months, when there are no mosquitoes.

A number of bats with their wings against their bodies were wound around and around with a string that gave them the appearance of little bobbins of cotton yarn; these were fastened to a long string by their legs and then whirled horizontally at great velocity for some time, the object being that the centrifugal force, by driving an excess of blood to the brain, might blunt that organ, and deprive them of the natural endowment of orientation. Another number of bats were fastened in like manner, but the position reversed, viz., fastened by the necks, and whirled around and around, to drive the blood from the brain. These severe ordeals had not one iota of effect on them, as, when liberated, they all behaved alike, quickly ascending quite high, and, after making a short circle, flying directly for home.



Mitchell's Lake Bat Roost. Erected April 2nd, 1911.

Mitchell's Lake Bat Roost. Erected April 2nd, 1911.

When bats are placed in a box the sides of which are covered with ¼-inch wire mesh, they soon huddle in some corner, hang in one or two bunches, and become perfectly calm. It is then that their heart's action and respiration can be so beautifully observed; the said heart's action slows down, and the rate of respiration is diminished by the contracting of the lungs. As it is normally at rest in a cave where the oxygenis almost replaced by the ammoniacal gases, the lungs contract to present less pulmonary area to the vitiated atmosphere.

Unlike a wild bird, the bat makes no frantic efforts to escape; and, in observing a single specimen, it can be handled with the greatest of ease, if we but allow it to get a hold with its claws or feet. As long as its claws find nothing to hold to, it is

very restless ana will bite and endeavor to escape. Its heart beat and respiration are then very fast, and it is ready for flight; but as soon as it finds something to fasten its claws to, both of these functions begin immediately to diminish. If after a little time we place it in the palm of the hand, it begins to turn its head from one side to the other in a very awkward manner as if to survey as long a range as possible; then its heart begins to run away, and its lungs to expand, when it will extend its wings, because its "motor" has acquired the requisite speed, and only needs to be thrown into action, to enable it to fly away.

If, after being kept in a screened box and not molested for a considerable time, a small aperture is made for the bats' escape, this can be beautifully observed, as, in the act of escaping, each bat rests on the outside of the box for a few seconds waiting for its "motor" to generate speed. If, however, we disturb them by vigorously shaking the box, and then allow them to escape, this lingering and awkward surveying at the aperture on the outside of the box does not occur, because they have prepared themselves for flight.

HARMLESSNESS OF BATS

About the only harm the writer ever has known a bat to do is that it will get into smokehouses and eat the fat from hams and bacon. If it can find a piece of bacon with the "streak of fat and streak of lean," it will eat the fat as far as its mouth will permit, and avoid the lean meat. Here it finds the necessary fat, therefore its struggle for existence for that year is over.

The facility with which a bat can compress itself into a small opening is a provision for protection against one of its most formidable enemies, chicken snakes. A bat can get into any long opening of the width of an ordinary lead pencil. The important parts of its anatomy are arranged by Nature for this facility. The author, some years ago, in observing bats in an old barn, killed a chicken snake that had swallowed fourteen bats.

The author desires very much to correct a popular impression which is a most unjust accusation against these valuable creatures; and that is that they carry bedbugs. As stated before, the long distances from their caves to suitable feeding grounds cause the bats to seek any dark hiding place, and they will sometimes get behind the loosened bark of a dead cottonwood tree, where is found in huge numbers in the immature stages an insect entirely distinct from the familiar human bedbug (Cimex lectularius). It is then that these larvae mechanically cling to the bats and are carried about by them until they either drop off or mature into the adult insect. The larvae, so closely resembling the true bedbug, are not such, as that insect does not thrive on dead cottonwood trees. The author begs to quote thus from Circular No. 47, United States Department of Agriculture, Bureau of Entomology, by C. L. Marlitt, page 4: "There is a prevalent belief among the old settlers in the West that the insect (bedbug) normally lives on dead or diseased cottonwood logs, and is almost certain to be abundant in log houses of this

wood. This belief was recently voiced by Captain S. M. Swigert, U. S. A., who reported that it often occurs in numbers under the bark of dead trees of cottonwood (Populus Montilfera), especially along the Big Horn and the Little Horn Rivers in Montana.

"The origin of this misconception—for such it is, so far as the out-of-door occurrence is concerned—is probably due, as pointed out by Professor Riley, to a confusion of the bedbug with the immature stages of an entirely distinct insect (Ardus sp), which somewhat resembles the former, and which is often found under dead cottonwood bark."

During the many years the author has been studying these creatures, he has never found a single bedbug on a bat. Some years ago he kept track of the number of bats he very carefully examined for bedbugs; and it amounted to more than four thousand. In bat caves, with millions of bats, there are no bedbugs to be found. In the bat roost at Mitchell's Lake in which are housed hundreds of thousands of bats, there has never been found a single bedbug. Bats are infested with a small louse, that looks something like a chicken mite, and also with a very beautiful specimen of "bird tick." These latter specimens of different species are found on doves, quail, and pigeons. The little louse on the bat will not remain on the human, as the writer knows from exposing his own person for a long time in a bat cave inhabited by millions of bats, for the express purpose of gaining this knowledge.

Bats seeking a resting place in the daytime during the migration period, will sometimes find such a place in dwellings, and usually under the roof; of course, they are very undesirable, though they have not gnawed their way in like a rat or mouse, but have found entrance through some defect in the workmanship, or perhaps because of a sinking of the building that leaves an opening for them to enter.

BATS' PLIGHT

The flight of bats, from the beginning of the feeding season to about the end of July, is very erratic; sometimes the flight begins as early as 6:30 o'clock p. m., and sometimes as late as 1 and 2 a. m.; and very often only about half of them leave their roosting places to forage. However, from the first week in August until the end of the season, they all fly out quite early, though some might be later than others. This is the most appropriate time for getting rid of them without injuring or killing them, in a very effective manner, which consists of simply closing the openings from which they are seen to emerge. It is perhaps well to observe out of how many openings they are emerging, and close all of them but one for some days before shutting the last opening; and, when this is done, it should be quite late in the evening, in order to insure all of the colony having left. In the morning after the opening has been closed the bats will return and attempt to re-enter by flying up to the closed place to get the preliminary hold with

the little nail or claw on the top of their wings. Failing to find lodgment, they will leave, and will be gone as much as an hour, only to return and again make several attempts to find their resting place. After several such repeated attempts they will leave for good; and the dwelling will be rid of them, for they will have found themselves a new home.

There is no winged creature that has such an amazing muscular strength to furnish it wing power. For instance, a bird will begin its search of food with the advent of day, but is on the ground, or perched on some limb, or sitting at rest at least two-thirds of the time. A buzzard or vulture will rise to a certain level by the flapping of its large wings, which in a most mysterious manner serve as a motorless airplane and enable the bird to soar for hours, without the expenditure of any considerable muscular energy.

Sometime ago the author had occasion to make a sea trip from Havana, Cuba, to New Orleans, La.; and his most interesting experience on that forty-eight-hour voyage was to watch the sea-gulls in quest of food. The skipper referred to them as "his old friends crossing the Gulf with him." They seemed to know almost the exact time when the table scraps and kitchen refuse were to be disposed of by dumping overboard, as they would then appear and follow the ship for miles.

When tired, they rested on the water and remained there for several hours, appearing again for quite some distance behind the ship, which they would gradually catch up with and continue their hunt for food. Their large wings, designed for rapid flight and soaring, with the surface of the water available for complete support, enable them to rest at least half of the time in the long journey of seven hundred miles across the Gulf of Mexico.

But our little friend, the bat, with comparatively short wings which it keeps continually flapping from 250 to 300 times per minute for 10 or 12 hours, and sometimes longer, with the additional calls for energy in making all kinds of dips, dives, and dashes through space in its quest of food, does not rest for one single moment from the time it leaves the roost towards evening, until it returns from its sanitary mission, back to the roost in the morning. The roost referred to here is what the author calls his " Mitchell 's Lake Bat Roost," a cut and description of which will follow later.

About one hour before emerging from the roost in the evening, the bats begin a small chatter, which gradually grows more animated, each individual seeming to take part in the conversation or argument and desiring to be heard. As the author has never even attempted to master the bat language, he will leave it to the conjectures of the reader as to what all the argument is about. But it is quite noticeable that some voices are louder than others and are heard more often; perhaps these voices are those of wisdom and come from the chiefs or elders who are advising or mapping out the route soon to be taken to

furnish them with their daily bread.

BATS EMERGING FROM ROOST

They first come out in singles, then in pairs, then fours, tens, hundreds, after which the procession becomes one black stream, and continues so for hours, usually breaking up into three columns and going in as many different directions, flying horizontally, each fellow hustling for himself. Their return in the morning is most interesting, and is well worth the inconvenience of having to get up early and travel ten miles out in the country to see.

They do not return as they fly out, horizontally, except some few who may be feeding in the immediate vicinity, neither do they return in pairs, tens, or hundreds, but ALL return at the same time from a high altitude and drop down when over the roost, around which they circle, so as to form a great black mass seventy-five feet in diameter. This huge mass keeps circling and circling the roost, and as those nearest the structure keep on entering, the bunch gradually gets smaller and smaller until they are all in.

Imagine all the guests in a great hotel to come home at once and to enter at the same time! What a crowded scramble that would occasion! The aisles and corridors would become congested, with the corresponding confusion and bedlam that would follow. Pa would be looking for and anxious about mother, and she in turn would be looking for and anxious about William, Henry, and sisters Lucille and Corrine. This is about what happens in a bat roost, when all the guests of such an institution return in the early morning hours. There is a great scramble inside the "Hotel de Bat," which has all the conveniences any little bat heart might desire. The more timid dart about in the flying space or corridor of the "hotel," awaiting room to be made by the more aggressive ones. All keep up one continuous chatter, which apparently has a different timbre from the evening chatter, due to a radical change in the theme, as now to them the hour of rest approaches, and the noise gradually diminishes as "Morpheus, the humble god that dwells in cottages and smoky cells," also dwells in their man-made home, the Bat Roost.

The high altitude the bat resorts to on returning in the morning to its roost or cave serves it in the remarkable purpose of not only finding its home, but finding it in safety. This return of the bats is indeed a marvellous sight! They are sometimes so high as to be entirely out of the range of vision, but when over the cave or Roost they drop down with frightful velocity; they close their wings, permitting gravity to accelerate the velocity of descent; and, when near the mouth of the cave, they gradually open their wings, to begin arresting their flight, and come down in a zigzag manner, something on the order of a tin disk sinking in water, then dart into the cave.

On coming out of some caves towards evening bats fly from

the dark and innermost recesses to a few feet outside of the mouth of the cave which they again enter for a short distance, fly out again, and re-enter, describing one continuous circle for a few seconds, before leaving their cave on their evening pilgrimage. They come out of the cave in such huge numbers that a stone carelessly tossed across the mouth of the cave is certain to strike one or two of these creatures. The current, or circulating air, they produce in flying in and out of the cave feels to one on the ground underneath them, like the blast under a four-bladed electric ceiling-fan going at a good rate of speed.

The circling and re-entering are caused by the fact that the ammoniacal gases continuously generated in the cave irritate their eyes so that they are kept closed, and the circling and re-entering at the mouth of the cave in the presence of daylight go on, until their eyes accommodate themselves to the light. This is truly a sight worth seeing, as for hours they emerge in one unceasing stream in their noiseless flight. Nothing breaks the stillness save the soft and muffled sound produced by the accidental touching of one another's velvety wings. The spectator feels awe and reverence for Nature, for here he sees the Old Lady in her pristine glory. We marvel as we peer into the darkness of the cave, and all latent superstition, recollections of fantastic dreams, and stories of the elves of darkness and gnomes in haunted houses told us in childhood are brought up from the subconscious mind in one bewilderment of thought.

A clapping of the hands at the mouth of the cave will cause an immediate arrest of the flight, and it will be a few moments before it is again resumed. A revolver fired at the mouth will keep them in for quite some time. This indicates the timidity of the creature. Towards the end of November, on a cold night, they fly out in the circling manner described in search of food, but soon return, and for hours as many can be seen going out as are returning. This is due to the fact that the heat caused by the decomposing guano gives them no inkling as to the status of the weather on the outside.

The flying out and re-entering of bats as observed at a cave, are not seen in a bat roost, as here there are not the irritating, pent-up, ammoniacal gases to contend with, because in the construction of their man-made home, the escape of these gases is provided for. This is accomplished without in the least changing other features, which are copied from Nature, and consequently so admirably meet with the bats' approval, as we shall see later on.

HOW BATS EVADE THEIR ENEMIES

If the individual who, in order to express his ideas of velocity coined the familiar slang phrase, "Like a bat out of Hell," should ever see a colony of bats returning home in the morning, he would substitute the words "cave" or "roost" for the word "Hell."

This natural manoeuvre is an admirable defense against one of their most formidable enemies, the chicken hawk. These birds of prey begin gathering in the near vicinity of a cave towards evening in anticipation of the bats emerging; and as the latter come out in such enormous numbers and fly horizontally, the hawks with the greatest of ease swoop down into the clouds of our little flying friends, and emerge with one, or sometimes two, one in each talon. Their suppers are assured, confirming the old Latin proverb, "Omnia sine labore," for they actually labor not in procuring their supper. Hawks are not to be seen in the vicinity of bat caves in the morning, as only too well do they know that they cannot match the velocity of flight the bat exhibits in returning home.

Some years ago the author spent many days, particularly the holidays in the spring and summer, at a bat cave a few miles from his home, studying these creatures, and was often accompanied on these excursions by several convivial friends who were much interested in the bat work; in fact, they were great "batophiles," wanting an outing and an opportunity to try their marksmanship in such a worthy cause as killing those big, strong birds, the hawks, that came there to devour our defenseless little friends.

Of course, liquid and solid refreshments were liberally provided for the picnics, and, as an incentive to do good work, a competitive pact was agreed upon, whereby the poorest marksman, or the friend who got the least number of hawks that evening, was to suffer the infliction of a fine, this punishment being no less than payment for the said refreshments. It is needless to say that the little picnics at the bat cave saved the lives of thousands of these beneficent little creatures.

MITCHELL'S LAKE BAT ROOST

At the Mitchell's Lake Bat Roost, the author and his friends have dispatched quite a number of hawks that made their appearance at the Roost just about the time the bats emerged. But there the bats are not so easy of capture as they are not as plentiful; and we applaud, when a big hawk, swooping down in the very act of capturing one of our inoffensive little friends, is frustrated by a clever and well-directed aerial dip, and the useful little life is spared to continue its activities in the service of mankind.

It is interesting to watch the small sparrow-hawk who comes to the crowded city in search of these creatures. This diminutive falconized bird, that preys on sparrows or other small birds, will perch on the ball of a flag-staff in the vicinity of places where bats are to be found, usually under some cornice, roosting during the day.

It also, like its big brother the hen-hawk, knows when it is time for the bats to emerge for their evening flight, and is seen on the flag-pole only toward evening. As the bats emerge, it

swoops down among them with wings partially closed to add velocity to its descent; but it makes very many fruitless dives, as the bat is such a wonderful aerial dodger that he side-steps his enemy, and before the sparrow-hawk can arrest its flight, the bat is safely on its way to the feeding grounds. When the bird does capture one, it proceeds right then and there to enjoy its meal. However, it is not long before some one gazing out of an office window sees him at his nefarious work, and as the bat has so many good friends in San Antonio, the murderer's career is soon ended with a silent 22-calibre bullet.

A very large barn-owl got in the habit of coming to the Mitchell's Lake Bat Roost just about dark for an easy supper. Of course the slow-flying owl is no match for the bat, but it got its supper, or perhaps its breakfast, with comparatively no exertion. It would appear about dark and flutter within a foot of the uppermost slat in the louvre, and, as the bats literally pour out of the roost at this time, some of them would actually collide with it, and of course get caught. It is needless to say that that particular owl does not make any more evening visits to the Mitchell 's Lake Bat Roost.

UPWARD FLIGHT OF BATS

If a number of bats are caught, transported for some distance, and liberated, they fly upward like wild ducks when shot at, and ascend so high as to become invisible. This is another protection from their arch enemy, the hawk. If the bat has a friend in the animal world, we have never made his acquaintance. At one time the author was transporting quite a number of bats in an empty flour barrel and one happened to escape. A large butterfly near by spied it and immediately gave chase, ascending higher and higher in close pursuit until both became invisible. The author wondered, like Mark Twain, when a small dog ran after an express train he was riding on, "What the dog would do with the train if he caught it."

BATS' WONDERFUL SENSE OF DIRECTION

In one of the preceding paragraphs it was said that the altitude in which a bat flies enables it "not only to find its home, but to find it in safety." We have seen with what admirable safety it reaches home, but not how it finds it. If, from some eminence with a good field glass, we observe a huge colony of bats emerging from a cave, they can be seen flying for miles. When they come to the crowded city and fly along the waterways, through broad streets, between high buildings, narrow alleys, and back yards, through mazes of telephone, telegraph, and electric wires, even entering our homes and churches in quest of food, we wonder how they can find their way back home. Won't they get lost traveling in the two extremes, wilderness and civilization *1* It would be impossible for them to become familiar with the region of their home, as their very small eyes afford them no long range of vision.

Unlike the human aviator, they have no object like a railroad track to guide them, or a compass set with mathematical accuracy to follow, neither are they equipped with a set of wireless instruments to direct them through the great empyrean; yet, with the unfailing accuracy of the compass, do they find their home and rest after a whole night of unceasing flight spent in the interest of humanity. Old Dame Nature has given them a faculty that serves them with the greatest ease, in that veering winds do not disturb the direction of their flight, when once the direction has been chosen.

This remarkable faculty is the wonderful power of orientation they possess. They know the exact direction of their home, whether a cave or a bat roost, and are guided accordingly. It is then that the sense of smell is brought into play, as when they find themselves over the cave or roost, no matter at what altitude, they detect the odor of the ammoniacal gases, which tells them that home has been reached, and then they drop down as described, following the odor. It sometimes happens that they drop down not straight to the cave, but at a decidedly acute angle. This is due entirely to the wind and to their direction.

The author some years ago in studying the habits of these creatures, camped near a bat cave and procured some spoilt hay. Early in the morning, in order to get the proper direction of the wind, he caused a smoldering fire to be built of the hay, and kept it smoldering to generate a large amount of smoke. The ascending smoke gave the exact direction of the wind, which, of course, carried the ammoniacal gases with it from the cave, and out of direct upward ascendency as it was wont to do, the gases being much lighter than atmospheric air. For several days the wind blew from southeast to northwest, and the bats were seen to be dropping from the northwest, after getting the odor. It also fortunately happened one morning that the wind changed from south to north, so did the descent of the bats change, as they began dropping from quite a distance from the mouth of the cave at an acute angle, and from the south, the wind blowing the odor from that direction.

Further to verify the observations of the remarkable faculty of orientation possessed by bats, one August morning the author with a large bag made of mosquito netting, caught, to be exact 2,004 of these creatures from a very peculiar cave, the surroundings of which furnished splendid environment for study. The cave is on the summit of a low, bald hill, and one of its mouths is a perfectly reamed hole in the solid rock, looking like a huge doodle-bug's home, the wide end being about 12 feet in diameter, the smaller end, or neck, about a foot and a half, and the depth about 10 feet. Out of this large rock funnel the bats emerge toward evening, but return through an entrance on the south side of the hill. Underneath this huge funnel is the beginning of the cave proper, which describes a semi-circle, and then merges into a beautiful, perfectly-straight corridor several feet in width, lined with limestone columns set as if by hand, five feet apart, and eight or ten feet high.

This is the hall and bower of a large colony of these valuable sanitarians, which the author so rudely invaded and pillaged on an experimental excursion. In a high-powered automobile the bats were taken to an open field about 30 miles from their home. Here the author liberated one bat, and watched its behavior. It took immediately to the air in the accustomed manner, and after describing only one small circle, with a velocity of flight that left no doubt as to its certainty of purpose, and made for the direction of its home. Four were then liberated; and, without the least confusion or separation from one another, in a very short time they got the proper direction and passed out of sight at a speed which would place a carrier pigeon in the pelican class.

But what of our screened box which we left in the open field with hundreds of our imprisoned little friends which we so rudely disturbed and carried away from their home and manor, thirty miles away? What might not be their heartaches, fears, and anxieties? Surely they must yearn for their loved ones, home, and rest, for were they not in peaceful repose, in one another's bosoms, richly earning a most deserved rest after a whole night's warfare in the interest of the family of that highest of beings, of which the arch disturber is a member?

Let us return to them, and give them our heartiest thanks for the noble role that their little lives play in giving us health and happiness, and restore to them that which Nature intended should be theirs, FREEDOM. Yes, we can, and will, do all this, but why not help these little dumb friends of ours to tell us more about themselves? It will lead to making friends for them when we tell of the great virtues possessed by these little mammals, who, emerging from their dim and cloistered domicile into the darkness of night, work valiantly in our behalf. They are equipped with faculties and endowments for destroying that fiend of the insect world, the mosquito, who carries a pocket of little living things and a hypodermic needle, ready to implant them in our bodies, and sow disease and tragedy within our homes.

While looking at the box, it occurred to the author to tie long narrow silk ribbons, highly colored, to ten bats, blind them, and liberate them (believing from previous experiments that, if the distance were not too great, they would go back to their homes), and drive back to the doodle-bug cave to observe their return. This might have added something to the knowledge of their habits; but, on reflection, the author who had willingly faced the dangers of rattlesnakes in dark caves in the interest of science, could not reconcile himself, though the call was strong, to the infliction of that degree of cold and studied cruelty of blinding these little friends of mankind, whom he so dearly loves. Chloroforming, cocainizing, suggested themselves as an incentive, in that they would alleviate the pain to be inflicted in carrying out the experiment. But the dictates of his softer nature prevailed; and, if a small leaf could be added to the garland of science by the display of such cruelty to that beneficent little creature, and name and fame were to be the reward, the author would remain unrewarded.

That there might be no possibility of error in confusing our bats in the box with some belated colony returning home, as they do sometimes come home in mid-summer quite late in the day, the author white-washed the bats in the box by drenching them through the wire meshes with a solution of prepared chalk, to the water of which some gum Arabic had been added to give it adhesiveness. After waiting for a short time for the water in the chalk solution to evaporate, the box was vigorously shaken, in order that they might get their "motors" in action; and then the door was opened wide. Remaining with the box long enough to see that the bats were escaping, the time was taken, and the high-powered automobile was raced back to the doodle-bug cave at a rate of speed which disregarded all traffic laws.

For a while during the race the bats could be seen, but after a time the bee-line from field to cave veered from the macadam road, and the bats, being so high, were lost sight of. The 28 or 30 miles from the field to the cave were covered in just fifty minutes. Selecting the best point of vantage with reference to the direction from the field and the wind, the coming of the bats was awaited.

Within eight minutes the vanguard appeared, then the larger numbers, and began dropping from a great altitude as described before, and darting into the side entrance of the cave. As by this time the hot sun and the wind had completely dried the prepared chalk on their bodies, leaving all manner of white stains on a black background, they could have been likened unto numbers of half-clad, or carelessly covered little elves. But they had not only reached their haven of rest through the agency of that wonderful and unfailing endowment such as only Nature can provide, ORIENTATION, but had reached it in safety.

BATS' CEMETERY

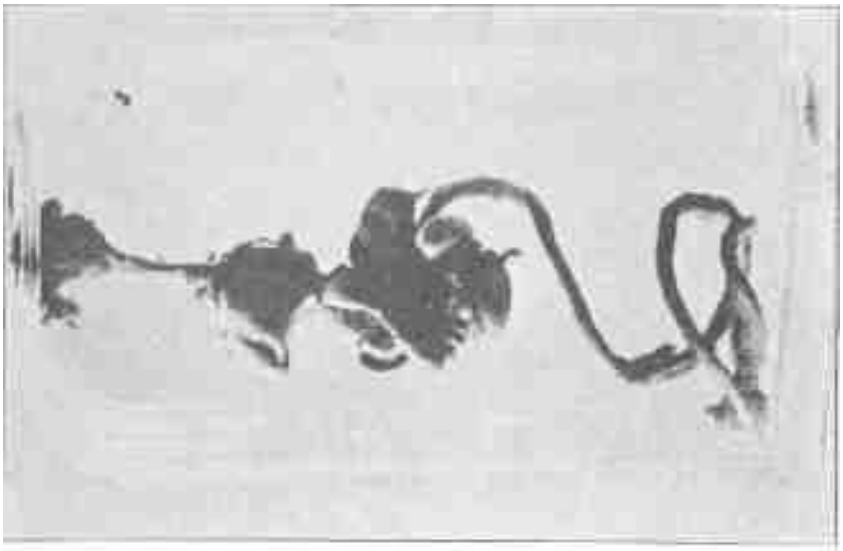
It would naturally suggest itself that some disease would break out among these creatures living as they do, so densely packed, yet in studying a well-tenanted bat-cave with 3 or 4 million bats making it their home, one is surprised at not finding dead bats scattered all over the floor, as surely on the part of some of these, Nature's last debt became due and was paid. A great many of these caves are from 20 to 40 feet high, twice or thrice as wide, and miles in length; yet we may cover hundreds of square feet without finding a single dead bat. People engaged in the business of emptying such caves for commercial purposes declare that bats must be very long lived, as they rarely find a dead bat in the tons of guano they remove from the floor of the cave every year.

As to the longevity of bats, this is quite true. The author has found many specimens perfectly grey, and with the dentine of their molars worn down smooth. As to the age of a bat, that would be hard to determine, but placing it at twenty-five or thirty years would be safe conjecturing. The lamented

microscopic luminary, Prof. Elie Metchniekoff, advanced the theory that all creatures without a colon, or large intestine, are very long lived, because they do not have a receptacle in which to harbor enormous bacterial flora, and in which are developed and thrown off the complex chemical substances that bring about old age. This statement applies to the bat, as it has no colon—which accounts for its longevity.

But our cave owners have not reckoned with the most wonderful of Nature's creation, as bats and a cave are purely a matter of business; for the guano, being the highest grade of fertilizer, finds a ready market, and when the annual crop has been gathered, the bats and their cave in the hum and bustle of commercial life are forgotten until it is time to harvest the next crop. But the student in search of knowledge, and endeavoring to unravel the skein of Nature's secrets, makes a most startling revelation.

Truly the dead bats are not scattered promiscuously about on the floor of the cave, nor are they covered by the guano that is being constantly deposited. No, a little close scrutiny will reveal the fact that all the dead bats are found in one little heap, in some dark corner of the cave. The colony has selected a resting place for its departed brothers.



Bat's Intestines.

Bat's Skull.

Top: Bat's Intestines. Bottom: Bat's Skull.

That this observation, so startling and uncanny, is not in error, is evidenced by the fact that the little bones are in one heap, perfectly intact. If the bats had been caught and taken to that spot by some wild animal, some of the delicate bones would be missing or scattered about. Very many skulls can be counted in the little bat cemetery. In the Mitchell's Lake Bat Roost where the author and owner has tens of thousands of bats, the extreme southwest corner of the Roost has been selected as the last resting place.

What emotions, pathetic or tragic, might be found in a cave or Roost among a little bat family! Is emotion, one of the faculties of the higher intellect, brought into play when they reverently select a place for their departed brothers? Surely it is not for hygienic reasons, as the dead are not remote from the living, but remain in the same surroundings, and the decomposition of their little bodies would not be any more detrimental to the health of the living than the constantly decomposing guano, their own excretory product. This is indeed most astounding and perplexing, for it is almost inconceivable that this creature, so low in the scale of life, should possess cerebral faculties which cross the boundary life of instinct into the glorious, God-given realm of REASON.

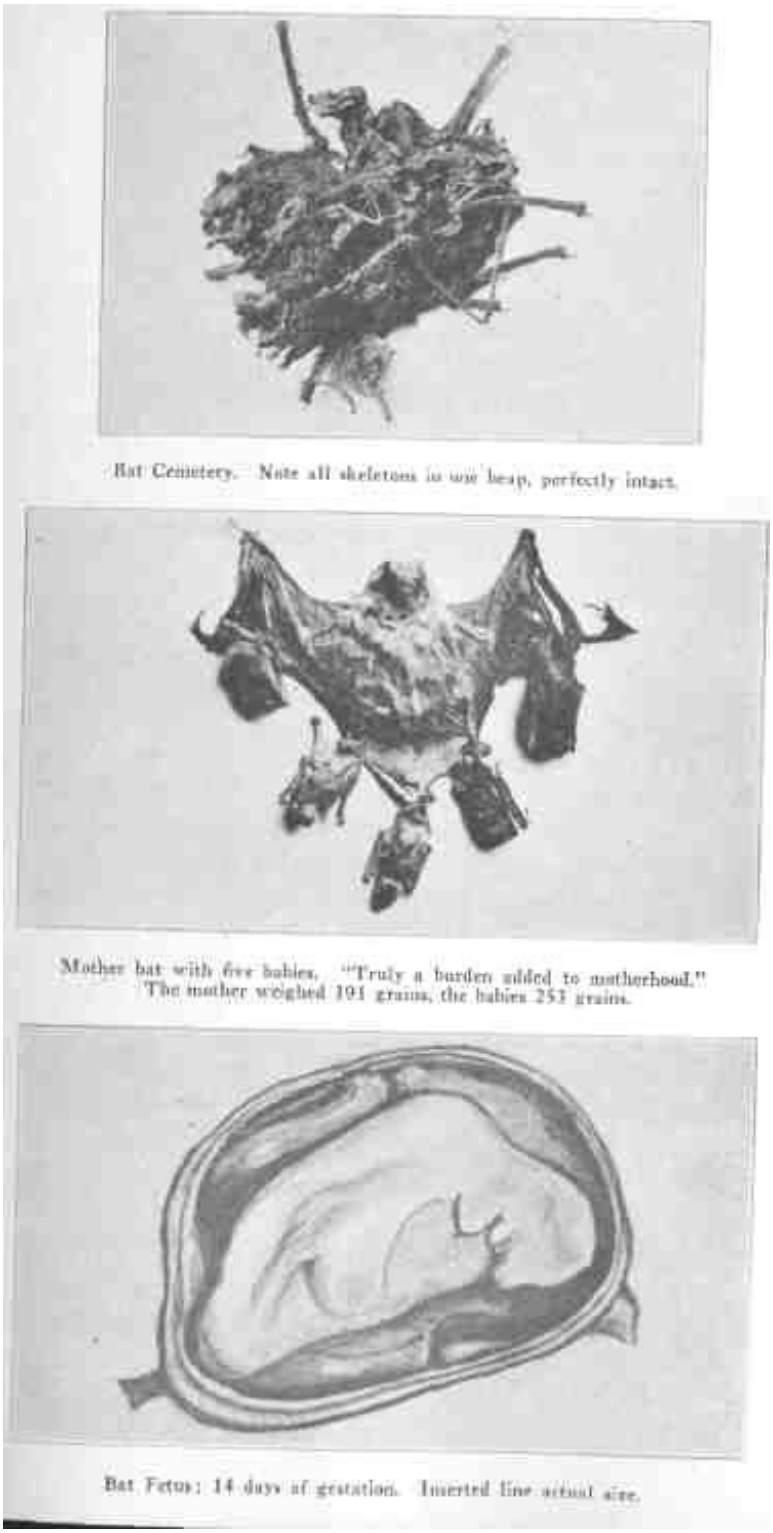
BABY BATS

In their natural homes, caves, is where the bat suffers the

greatest loss, particularly to their young. The baby bats from the time they are born cling mechanically to the mother, as she builds no nest to rear her young. The mother bat, in her long nocturnal search for food, carries her babies with her. Truly a burden added to motherhood! The author during the summer of 1915 caught a red bat mother "Nyctinomus nevoboracencis," who had five babies clinging to her body. She seemed to know them individually, as she allowed them all to take their turn at nursing; when she thought one had had enough, she would push the one nursing off with her nose, the hungry one being close at hand to take the nipple that had just been vacated, and in that manner she apparently was rearing her burdensome family in great contentment. She truly was a mother and had her burdens to bear, as her five babies weighed 253 grains, and she, the burden bearer, weighed only 191 grains. This species of bat, I do not believe, is gregarious.

The high ceiling of a cave to which the bats cling and roost is one of the features that cause them to make it their home, as it protects them from wild animals. A cave with a low ceiling, no matter how inviting otherwise it might be, is certain not to be tenanted by bats, even if its mouth be situated on the face and in the middle of a high vertical cliff, where it would be impossible for any wild animal to reach. This unquestionably is an inherited instinct, as it involves one of the most potent features in the continuance of the species, viz., the protection of its progeny.

Bats have the remarkable faculty of being able to compress themselves into very narrow spaces. In fact, the space is limited only to the median diameter of their heads, which is about 5/16 of an inch. The sternum or breast bone is well adapted to this flattening facility; and to insure it against injury in the act of taking advantage of this faculty for its protection, Nature has placed the testicles of the bat in the abdominal cavity, and has thoroughly covered the reproductive organs on the outside of that cavity with a long prepuce. It is quite obvious that the animal's anatomy should harmonize with its habits; and this gives us another view of the faultless works of Nature. If the reproductive organs were placed on the outside of the abdominal cavity, they would perhaps become injured in the bat's struggling to compress itself into a small opening; and the resultant injury to that important organ would mean an interference with the continuance of the species. Dame Nature, sometimes herein referred to as "The Old Lady," is infallible; she makes no mistakes. This avenue of defense is directed for its protection against one of its most formidable enemies, the chicken snake.



Bat Cemetery. Note all skeletons in one heap, perfectly intact.

Mother bat with five babies. "Truly a burden added to motherhood." The mother weighed 191 grains, the babies 253 grains.

Bat Fetus: 14 days of gestation. Inserted line actual size.

Top: Bat Cemetary. Note all skeletons in one heap, perfectly intact. Middle: Mother bat with five babies. "Truly a burden added to motherhood." The mother weighted 191 grains, the babies 253 grains. Bottom: Bat Fetus: 14 days of gestation. Inserted line actual size.

Coons, opossums, wild cats, skunks, civet cats, and all kinds of snakes are the bats' principal terrestial enemies, but these are found in caves only for a short time during certain months, after the babies are born. They well know that it would be useless for them to try to obtain food in a bat cave at any other time, and they not only know the propitious season, but they also know the ease with which it can be obtained.

As said before, the baby bats cling mechanically to the mother with the clawed feet, hooked thumb, and a tuft of hair in their mouths; and when the mother returns to the cave after her long and burdened nocturnal pilgrimage in search of food, she is well-nourished and better fitted to continue her maternal functions, but sorely in need of the rest and sleep she finds in her home. Her wings, now having so admirably served the physical, become mantles of love as she wraps her baby in their velvety embrace, knowing the danger that lurks underneath, and goes to sleep.

Like all babies, human and other kinds, when its "tummy" is full, it also will go to sleep. Here is where it will often loosen its hold; and, as it has no cradle or nest to rest in, it falls to the floor of the cave on the soft guano, but, by spreading its little wings, it manages to break the fall so as not to injure itself. This awakens the mother bat, who, finding her precious charge missing, immediately darts down to the floor over which it flutters and scrambles in a very awkward manner, usually finding many babies, but halting only for a second or two at each one, to ascertain if it is hers, until she finds her own, which she does with unequivocal certainty. Then with a few caressing licks on its naked little body, and perhaps uttering words such as can be articulated only by the divine promptings of motherhood, she causes her little babe again to cling to her, and then she flies back to her place and safety.

But here again we see Old Dame Nature asserting her inexorable laws, as she causes some of her other creatures, the wild animals, to lurk in the cave awaiting just such contingencies, in order to catch and devour not only the defenseless baby bats that fall to the floor but also the mothers who come down after them.

A Bat Slayer Slain

When camping near a bat cave to study these creatures at first hand, a very rare opportunity was afforded the author to witness one of the tragedies that befall these valuable little mammals in their homes—tragedy, as it appears to us, but in truth merely the promptings of Nature, the dictates of whose implacable laws find no association with kindness, pity, or cruelty.

It is impossible for one to look directly upward in a bat cave, on account of the great numbers of bats hanging so densely to the ceiling and continually dropping guano and urine; but this cave afforded excellent facilities for observation, in that a niche, or recess, resembling somewhat a bay window in the vertical wall, formed by a large piece of stone which had detached itself and fallen inward, made an excellent retreat. From this point of vantage the eye could sweep the cave in one direction as far as the darkness would permit, and in the opposite direction to the mouth, some thirty-five or forty feet distant. Here one could sit by the hour, observing these most peculiar creatures, away from the excretory showers, and with a

reasonable degree of comfort, as the observation point was near enough to fresh air to overcome somewhat the ammoniacal gases, at least to the point of tolerance.

The entrance to the cave commences with a descent at an acute angle from the surface of the low hill to a depth of about twenty-five feet, where the mouth proper begins, the entire opening in the ground being about thirty feet in diameter. The emergence of the bats toward evening and their return in the morning had been noted from the outside and from the mouth of the cave; and the author, being desirous of observing their behavior in the cave immediately after their return in the morning, stationed himself in the mentioned niche long before daylight, so as to await the coming of the bats. The outlines of the rim of the crater leading to the mouth could be plainly discerned from the inside by the starlight.

After an hour of patient waiting, the monotony of intense stillness was broken by the sound of the loosening of small stones, and on looking in the direction of the rim, the figure of a large wild cat was made out. As he half turned to begin his descent, the outlines of his head were seen, then his tail last, the occasional faint sound of a loosened stone indicating that he was making for the inside of the cave. How far he had entered, of course, could not be told, as his steps became perfectly noiseless on account of his soft paws, and the soft and yielding guano. The thought of being associated with a wild animal in a close place, and in inky darkness, was not very pleasant, particularly when its course or direction was not known. The author, however, was provided with a sawed-off shot gun loaded with buck shot, which gave him every assurance of safety, as marksmanship with such a weapon at short range is quite an unnecessary accomplishment, its results being unfailing.

However, with eyes and ears wide open, the stillness being almost painful, patience was beginning to become a grind, and threatening to overthrow the enthusiasm for original scientific research, held in leash only by the delightful anticipation of the uncertainty of coming events. Conjectures of all kinds floated through the long dark vigil for daylight—fear lest some little noise, sneeze, or cough might scare away the creature whose presence promised so much. Would his sense of smell tell him of the presence of an enemy? Would his keen ears hear the human breathing? The long-wished-for time began to send in little, dim rays of light, which became gradually brighter, until the fortunate sight was afforded of the cat, with its head opposite to the niche, crouched down, and like his fellow visitor, awaiting the return of the bats. This was most pleasing, indeed, because of the assurance of perfect observation of the cat's behavior, as he would not be frightened away by seeing an enemy. It even appeared to relieve the soreness induced by a cramped position.

The vanguard of the returning tenants soon appeared, closely followed by the great army, and to one of the trespassers, they were very welcome, as each little private caused a little

complement of fresh air to follow it, the lack of which was beginning to be sorely felt. To this great army the cat paid no heed whatever, well knowing his inability to reach the incoming bats, as they flew but a few feet below the twenty-five foot ceiling.

But neither idle curiosity, nor the spirit of investigation brought him there; he came in quest of food, as doubtless he had often come before, and he knew that all he had to do was to bide his time. He did not have long to wait, for shortly after all the bats had entered the cave, and each one had found its place, the chattering gradually ceased, and, with the exception of a few noisy ones who perhaps had some argument to settle, all again were still, and Morpheus reigned supreme.

Presently a baby bat fell to the floor of the cave within a few feet of the cat; it made a short leap and placed its paw upon it, making no attempt to devour it, but looking rather upward as if in expectancy. He was not in the least disappointed, as in a very short time the mother bat, in obedience to that angelic instinct, Motherhood, came down seeking her baby, when the cat got her, and she paid the extreme penalty with that resignation only mothers know. Why didn't the cat immediately devour the defenseless little baby bat? Did he know that the mandates of maternal love would send the mother down after her baby, and so held it captive under his paw? He evidently did. Overwhelmed with a wave of rage at the sight, and hearing the little bones crunched, with words intended for its requiem, but which are not generally used on such occasions, the spectator arose from his crouching position, and gave the cat as he was running for the inclined entrance, the contents of one barrel of the gun, which very effectively ended his career as a mother-and-baby-eater.

After the commotion among the sleeping inmates brought about by the shot had subsided and quiet again ruled, quite a number of baby bats were seen to fall to the floor of the cave, and the mothers to dart down after them and pick them up. Prom the number observed to fall, the cat would unquestionably have had a bountiful feast, as doubtless he had often had before.

Is this great destruction of the most valued friend of man one of Nature's schemes in continuing her alleged "balance?" It may be so, or it may not, but the fact remains that countless thousands, perhaps millions, of these arch enemies of the fiend of the insect world serve as food to other creatures, while to us they are purveyors of health, and the death of only one represents the distinct loss of one sanitary worker. We are truly in need of all of these creatures that Nature can provide, and it consequently behooves us to employ our God-given gift of REASON to disturb that "balance" in our own favor by putting an end to such destruction. Can this be done ? Yes, it can; and we need no long nor expensive experimentation to ascertain this fact, for the method has long passed the experimental point and become a settled fact, as we shall see later on.

A great many dissections have revealed the fact that the love-making season for bats begins about the middle of April, and that the babies are born about the end of June or the first days in July. Procuring specimens from one place, dissections were made every two or three days, up to and including the 14th of April. For reasons over which the author had no control, no more dissections were made until the 28th of April, when all the females were found pregnant from the very earliest stages, to the size of the fetus shown in the photograph, which with all certainty can be said to be about 14 days old.

For a few days before, during, and after the babies are born, an *"affaire domestique"* takes place in the lives of these creatures, whether in their natural or artificial homes, that is not only most interesting and peculiar, but grippingly perplexing.

In a bat roost where tens of thousands make their home, they seek the innermost and darkest places which have been provided for them for just this purpose, and keep perfectly quiet. Not a sound of their high squeaky voices is to be heard; they also have laid aside for the time being their quarrels and their fussy nature. In a cave, where literally millions make their home, the same conditions obtain; they seek the darkest places in the cave, sometimes perhaps a mile from the mouth. Some few will fly out very early in the morning, 2 or 3 o'clock, and remain on the wing only for an hour or so, perhaps to quench their thirst in the dew-laden air; but, on returning, they make not the slightest noise. As no wild animal or snake ever goes into a cave for any great distance beyond the mouth, from these they are well protected; but it seems that it is not so much for protection that they seek these dark hiding places, as it is to convert them into lying-in quarters.

But why should ALL resort to these quarters? "What role, if any, does the male, or papa bat, play at this particular time? If he has any to perform, we could understand that he should join his mate and be a solace and source of comfort during her trials. But there are many who are not papas, or even prospective papas, and but very remotely, or not at all, kin to the new arrivals, and could have no interest in their welfare; these would be perfectly safe in the forepart of the cave where they usually find their place during all of the feeding season, except for these few days. Wherein does silence become so vital or so essential to the welfare of the home? That it serves a purpose is unquestioned, as it is prompted by the implacable dictates of Nature.

This perplexing trait exhibited by the bat about the time the young are born occasioned a very pleasing and amusing incident. A stockman who has in the hills of his extensive pasture a very large and lucrative bat cave, happened to be looking after his cattle in the vicinity thereof; and, it being toward evening, it was perfectly natural that he should glance in the direction of the cave for the flying bats, as these

creatures were a source of revenue to him without carrying any overhead expense, and were more certain than the cattle. He saw no bats. Consulting his watch, he grew apprehensive, as it was time for the flight. To allay his fears, he rode up to the mouth of the cave; but, truly, not a bat was to be seen. Dismounting, in order to make a closer inspection, he went into the cave a short distance and listened for quite some time. The longer he listened the denser the stillness became, and the more his anxiety grew.

As darkness was fast approaching, he rode back to the ranch house in a very crestfallen mood, brooding over the loss of the millions of his little friends who contributed so bountifully toward those whose happiness was his. What was the matter? How did it happen? What had caused this exodus?

With the "hope that springs eternal," etc., he consoled himself with the thought that perhaps the bats had all flown out before he reached the brow of the hill from which he made his first observation. However, the prospective loss of seventy-five tons of bat guano, that most valuable of all fertilizers, which his cave yielded him annually was not so easy to banish from his mind. Mental pictures of the thick black columns of bats, as he had so often seen them leave the cave, coupled with the regrets for financial certainty of the never-failing guano crop to meet plans and obligations carefully laid, but now ruthlessly swept away, made a very restless and sleepless night for him. He "eagerly wished the morrow," that he might be at the cave before daylight, and get "surcease of sorrow" at the entrance of his financial shrine.

Long hours before the first rays of the peep of day found our friend seated on the outside of the cave; and, as daylight approached, his hopes instead of the bats, found their place in the darkness of the cave. One more little hope! Perhaps the bats came in during the night? Again he went into the cave, deeper than the evening before, emerging entirely resigned to his fate. His bats were gone. Hastily arranging matters about the ranch for a few days' absence, he came to the city to call on the author and tell him about his great loss. His sad story, told with a most woeful face and long drawn out, was patiently and respectfully heard, the listener assuming the role of a deeply-sympathizing friend; but when the feigned sympathy could no longer be controlled, the author broke out in a most uproarious laugh, at which his friend was not only amazed but took deep umbrage. Thinking the joke had been carried far enough, the author then informed his friend that not only did he have all the bats he ever had, but a wonderful increase. The ranchman's joy then knew no bounds; he jumped from his chair with the enthusiasm of a boy, and promised the author one of the finest country dinners, if it proved true that his bats were simply having their babies. As to the Texas "cowman," his word is an integral characteristic; and it is needless to say that a magnificent repast was enjoyed by all who attended the "baptismal feast" —an entertainment that will long be remembered.

Some day the author means to build a bat roost, of course strictly according to the known successful plans, but he will have a secret "observatory" constructed on the inside for his own use, in order to be able actually "to move and have his being" if not "live" among these wonderful friends of mankind, and to get a more intimate acquaintance with their home life by careful study. If a second edition of this book is ever to be written, the author hopes to answer therein many perplexing questions which must now be left to the conjectures of the reader.

The first instance of the real practical value of bats as destroyers of mosquitoes, particularly the night or malarial ones, came under the author's observation in his private practice, and served greatly to encourage his enthusiasm for the continued study of these wonderful creatures.

About five miles from the City of San Antonio in a westerly direction is a farm irrigated by an elevated wooden tank and windmill, and also a big earthen tank holding a large amount of standing water. Scattered about the farm were many one-inch leaky faucets creating as many little pools of stagnant water. Bach of these large tanks and the many little pools formed ideal mosquito-breeding places; but in them there were also bred thousands of dragon flies of many varieties. These could be seen disporting themselves all day long.

During the years of 1906 and 1907, this farm was tenanted by a widower and his two little girls, aged 12 and 15 years respectively, and in the summer they slept on cots on the galleries of the house without even thinking of mosquitoes, mosquito bars, or screens, for they never heard the singing of a mosquito about the place. In the early part of 1908, a portion of this farm was rented to a tenant whose family consisted of himself, his wife, and four grown children. A very high barn on the place was renovated by the new tenants, and the lower floor was converted into living rooms. One evening in the early spring, noticing that a large number of bats were coming out from under the roof of the barn, the tenant and his family proceeded to kill the bats, and prided themselves on having destroyed "over two washtubfulls of the pesky critters." Soon afterwards, the old tenant and his little girls found they could not sleep as formerly on the open galleries, as the place was swarming with mosquitoes; and his children and those of the new tenant were soon ill with a severe type of malarial fever. The mosquitoes came only at night, beginning with sundown. It is plainly evident that the dragon flies held down the diurnal mosquitoes during the day, but the destruction of all of the bats had left the night mosquitoes unmolested, hence the malarial infection naturally followed.

WIDE EXTERMINATION OF MOSQUITOES

As mosquitoes are the chief article of diet of bats, particularly the nocturnal varieties which convey malaria, these animals must be reckoned as the arch enemy of the insect; and,

as the mosquito is man's arch enemy, the bat ought to receive the highest recognition as a valuable hygienic agent. In order to ascertain approximately how many mosquitoes a bat would destroy in its nocturnal wanderings in one night, the following experiment was carried out: Knowing of a hunter's small cabin some ten miles from the city where bats were congregating, the author procured two large white sheets and spread them on the floor of the cabin about 4 o'clock in the morning, and awaited the coming of the bats. The roosting places had, however, been stuffed with rags so that they could not roost out of the range of the area of the sheets. A careful watch was made of the number of bats going in; and the count was verified from the inside of the cabin. Then they were left alone, but counted again in the evening as they flew out. After noting that the same number went out as were counted going in, the many pellets of guano that had accumulated on the sheets were carefully collected, placed in a small pill box, and the sheets again spread out, to continue the experiment the next day. This was done three times consecutively, with the result that the count averaged 26 pieces of guano for each bat. Having ascertained approximately how many times a bat dropped guano during the day or its resting hours, one dropping or single piece of guano was macerated in peroxide of hydrogen for several days. The peroxide dissolved the oxidized and concreted mucus holding the little mass of guano together; this was then filtered through ordinary filter paper, the weight of which had previously been accurately ascertained, and the residue found contained principally the comminuted skeletons of mosquitoes—their probosces, heads, legs, wings, thoraces, abdomens, and scales. The external body of the mosquito, being of the horny substance already defined as chitin, affords the bat no nutrition; for it is absolutely insoluble and hence passes through the alimentary canal undigested as fecal debris. The weight of this filtered residue of one bat-dropping, was approximately 1/25 of a grain.

One hundred mosquitoes that had never been engorged, i. e., which had been raised from the eggs, then, after being hatched and kept under netting all of the time, had been allowed to starve, were thoroughly dried and were comminuted by being rolled over and over by a half-inch steel ball in a porcelain dish. They weighed, after being macerated in peroxide of hydrogen as was the guano, approximately 2/5 of a grain. It follows then that every dropping of the bat contains approximately the skeletal remains of ten mosquitoes. This much of the experiment is correct; and, if we continue the figures in accordance with the findings, we shall see that the bat must be credited with consuming in one night, as represented by the number of pieces of guano it drops during its resting hours, 260 mosquitoes. Without any further investigation on this point, due to the correctness of the experiment, the author at the time accepted these figures; but from the extraordinary reports made to him by the tenants of the Mitchell's Lake lands as to the disappearance of malaria, and from his own observations of this fact and of the large diminution of mosquitoes, he was led to conclude that he was not giving the bat its just deserts; in

fact, was materially underestimating its great hygienic value. The immense clouds of mosquitoes that used to come down on the tenants in the work of irrigating at night, which phenomenon they described as "like being bombarded with handfuls of bran," had unquestionably disappeared, but the conditions under which they bred had not changed one iota. There was nothing that could have brought about this modified condition except the great increase in the number of bats. None appreciated the changed conditions more than the tenants of these lands; and we are bound to concede that these people who live there year in and year out are really the best and most competent judges of the conditions and environments of the locality where they live.

Again, enlisting the services of his old, faithful friend, the author made very many observations during the late summer and fall of the year 1917, and continued the said observations during the summers and falls of 1918, 1919, and 1920, and the summer of 1921. The results thereof place the bat on the high pedestal of preventive medicine as a most wonderful hygienic agent, and account satisfactorily for the eradication of malaria and the changed conditions at Mitchell's Lake.

It will be recalled that the Mitchell's Lake bat roost was erected on these lands on account of the ideal conditions for the propagation of mosquitoes and malaria which exist there; and, as said before, no swamp in the low lands could possibly be worse. The entire sewage of the City of San Antonio, amounting to 15,000,000 gallons daily, finds its way into this lake.

The observations were extended over the five years mentioned, on account of the extreme difficulties encountered in their making. Specimens of bats were obtained only between the hours of 9 p. m. and 3 a. m. Many and many an entire night was passed without procuring a single specimen. If some enthusiastic student should care to carry on this work with a view toward its verification or improvement, he will appreciate the difficulties under which he must labor.

PROOF OF BATS' MEALS

When the bats return to their roost in the morning, which is usually about 4:45 o'clock, and sometimes much later, they can be easily captured, but it will be found that there is little or no food in the stomach. The stomachic digestion, which is very rapid, has completed itself, and the pellets which the bat voids during the day represent the food which was undergoing the intestinal digestion when it reached home. The blood from the mosquitoes' abdomens or their albuminous internal organs, if it should have been caught unengorged, is rapidly digested, leaving only the chitinous insoluble hulls, which are so thoroughly comminuted by the sharp chopping teeth and the rapid mastication that they require the low power of the microscope to be seen.

In the course of the five years mentioned, the many specimens procured were marked with the time of capture, and on return to the work room were carefully dissected, the stomachic and intestinal contents being painstakingly weighed, or else placed in a solution of formaldehyde until that could be conveniently done. Without going into the details of this tedious, expensive, and laborious experiment, extending over the years mentioned, the results as found were, that the minimum of the stomachic and intestinal contents weighed 18 grains, and that the maximum of the same weighed 42 grains. Thirty grains, therefore, is the average weight of food the bat consumes in one night's feeding. To be very conservative in arriving at the approximate number of mosquitoes a bat will consume in one night's foraging, let us deduct fifty per cent (50%) of this weight as being due to moisture. This will leave us 15 grains.

In one of the preceding paragraphs, we have seen how and under what conditions the weight of one hundred mosquitoes was ascertained, and that it amounts to 2/5 of a grain. It follows, then, that the fifteen grains represent the weight of 3,750 mosquitoes, consumed by *one* bat in one night. For additional conservatism, let us deduct ten per cent for food other than mosquitoes, which would be small, plant-sucking insects, leaving us a grand total of 3,375 mosquitoes. When it is taken into consideration that the experiment from which these figures are derived, represents the food ingested by the bat from the hours of nine o'clock at night until three o'clock in the morning, we enhance the conservatism by not taking into account the ingested food after three o'clock in the morning.

It would be very conservative to estimate the number of bats as permanent residents at the Mitchell's Lake bat roost at two hundred and fifty thousand, though when the period of migration is well established the number could be just as conservatively estimated at more than half a million. If the reader will take a slip of paper and pencil and do a little multiplying as per figures given above, he will be astounded and amused at the results he obtains. The estimation of the food of bats other than mosquitoes, given at ten per cent, is arrived at in a very singular but convincing manner, and is furnished by the guano itself.

If we will take indiscriminately a quantity of guano, just as it is found in the hopper of a bat roost or on the floor of a cave, toward the end of the feeding season, and make from it many little heaps, each containing by very careful count one hundred pellets of guano, we shall be astonished at the regularity with which we find each little heap to contain ten dull, straw-colored pieces of guano or pellets, readily distinguished from the ninety ordinary, coal-black ones. Of course, some of the hundred heaps will contain more and some less of these dull-colored pellets, but the averaged ten per cent remains constant.

As the bats feed on mosquitoes, and mosquitoes feed on blood, it is but natural that the excrement or guano of bats should be black, because it is the iron in the blood that imparts

the black color. In fact, the enormous iron content in bat guano affords a most convincing argument as to the food, as has been shown by chemistry. The dull, straw-colored pellets represent the skeletal remains of insects other than mosquitoes, that carry no blood, hence contain no iron, and therefore do not give the pellets the black color.

However, this ten per cent deviates during the first month of the feeding season, which begins in this climate, about the 15th of February (San Antonio, Texas, Latitude 29° 27' north—Longitude 98° 28' west of Greenwich).

For many years past, the author has observed that three things happen simultaneously in this vicinity, with almost clock-like regularity. The mosquitoes emerge, the swallows arrive, and the bats begin to fly, their feeding season having begun. This happens on February 15-16th, hardly later than the 17th. For the first month of the bats' feeding season the guano pellets do not exhibit the ten per cent of dull, straw-colored pellets, the percentage then being barely three. The reason for this is that mosquitoes begin their flight before other insects develop in the new year, and hence are correspondingly more plentiful. As a verification of this observation, a chemical analysis of the guano dropped during this time shows one-eighth of a pound of iron more to the ton than does that dropped during the rest of the year.

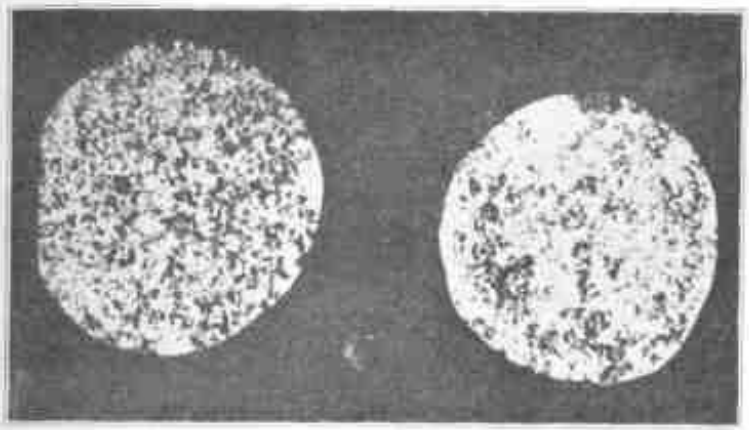
The photo marked "Mosquitoes and Guano" shows how "identical ground mosquitoes and ground bat guano are. The one on the right is pulverized guano, and the one on the left is ground mosquitoes.

This most interesting feature revealed in bat guano opens to the student a wide field in determining the nature of the food of bats, other than mosquitoes, and which may bring added nobility to this most wonderful of Nature's creatures. The author has been at work on this feature in the scatology of bats for quite some time, and hopes some day to find evidence of such a nature as will win for the bats encomiums galore. It will be possible to demonstrate that in addition to this wonderful creature's habits in preventing sickness and tragedy in homes, and increasing man's crops, it puts more dollars in his pockets by protecting his fruit.

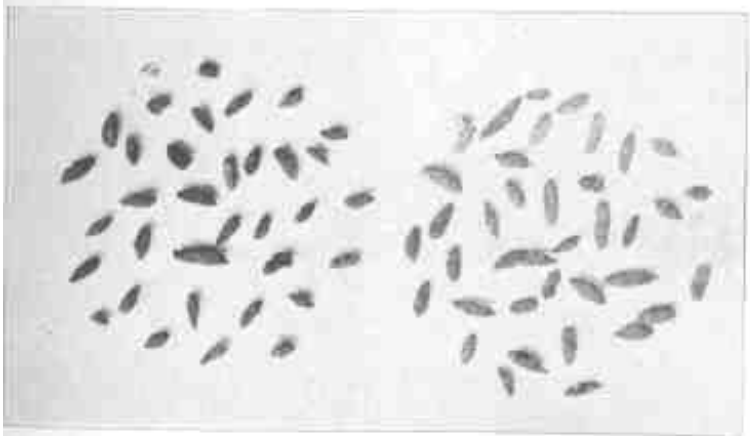
In this connection, the author quotes the gist of a letter he received some time ago from a gentleman in California. The letter in some manner became misplaced, and if this little volume falls into his hands, he will recall the correspondence, and will, it is hoped, again communicate with the author. The letter was occasioned by the writer's seeing an article on bats in a newspaper. His words in addition to being laudatory of the author's work, gave information to the effect that a brother of the writer has an extensive orchard in British Guiana, in a region noted for fruit growing. To encourage the fruit industry, the Government offers a prize for the orchard showing the greatest freedom from pernicious insects. The previous year his brother won the said prize; but his neighbors some two miles in

each direction, who worked as hard as he did, to keep their orchards in fine condition, not only were not so rewarded, but one of them had his orchard condemned. The brother orchardist, after very careful observation, ascribed the freedom of his orchard from pernicious insects to the activities of a colony of bats that made one corner of an old barn on the premises their home. This incident, like the incident of the bats in the high barn on the irrigated farm previously mentioned, and which gave the author such an encouraging and helpful clue, might well afford a valuable hint to the American orchardist.

Bat Guano (Chitin); showing skeletal remains of insects, principally mosquitos.



Bat guano and mosquitos ground, guano at right. Note the similarity in the two pictures.



Yellow and black bat guano.

Top: Bat Guano (Chitin): Showing skeletal remains of insects, principally mosquitos Middle: Bat guano and mosquitos ground, guano at right. Note the similarity in the two pictures. Bottom: Yellow and black bat guano.

Can the reader imagine a more valuable possession than a well-tenanted bat roost on his farm or country place? To begin with, his family is protected against that form of tragedy presented by disease, with the concomitant suffering, anguish, anxiety, and perhaps mourning. But he doesn't keep all this protection to himself; his neighbors, perhaps less fortunate than he in the possession of this world's goods, share it with him; and what a proud satisfaction he must enjoy in the knowledge that these neighbors and their little children are enjoying the same protection with him, while in the hopper of his bat roost there is accumulating the agent that will more than double the output of his vegetable garden, and not only furnish food for the fruit trees in his orchard, but also rid them of the pernicious insects that hinder them from being healthy and bountiful-bearing !

That bats must have a selective instinct for finding the engorged mosquito is in no better way shown than by the enormous and almost unbelievable quantity of blood they consume. This is indicated by the iron the guano contains. This unassailable point is demonstrated by no experience, observation, or experiment the author might have made, but by that cold-blooded branch of science, known as chemistry. Any one with an elementary knowledge of inorganic chemistry can prove it; and it will give positive information. In the analysis appear two technical terms—hemoglobin, which is the red coloring matter of the red corpuscle, and chitin (pronounced ki-tin) already defined in Allegation One. The analysis is founded on the fact that hemoglobin contains 0.42 of one per cent of iron, and that blood contains 15 per cent of hemoglobin. As the analysis is quite pertinent to the study of the spleen, the reader will find it given here in after tinder the heading, "FUNCTIONS OF THE SPLEEN."

In ALLEGATION FOUR it is stated that the Mitchell's Lake bat-roost will average a production of two tons of guano annually. Analysis reveals the fact that two tons of bat guano represent about 6,350 pounds of liquid blood. Yes, but this is only the guano dropped in the roost during the day, while the bats are resting. Is it not good reasoning to assume that the bats that make the Mitchell's Lake roost their home drop as much more guano during the night whilst feeding, which guano is scattered broadcast in their aerial flight? This means that the myriads of tenants of this little building consume in one year some 12,700 pounds of liquid blood. Figures run riot when we attempt to compute the number of mosquitoes these bats must catch (each to provide a tiny drop of blood in its little abdomen), in order to collect and digest more than six and one quarter tons of liquid blood. After one seriously attempts to make such a computation, the eradication of malaria ceases to

appear to him such a wonder.

It would naturally suggest itself that an excrementitial product, comprising such an 'enormous quantity of blood, would be an ideal breeding place for myriads of house flies, and, by the continual burrowing of its larvae, keeps the these noxious insects. Such, however, is not the case, as flies do not breed in bat guano.

A small brown bug, the name of which the author does not know, as if to contribute to the general good of a bat roost, finds a home and food in the guano, where it breeds in large numbers and serves several useful purposes. It adds nitrogen to the guano, breaks up the pellets into powder, which makes the spreading of the fertilizer a matter of 'ease, and, by the continual burrowing of its larvae, keeps the guano level, and allows the hopper in the roost to become evenly filled.

The roost is, indeed, a very complicated structure, embodying all the different features demanded by Nature and found in a well-tenanted cave, a flying space, a hanging space, and a hibernating space, being the essential features. A "lost space" involved in the construction is also very profitably utilized.

As our country grows in population, agricultural areas must be opened up; in fact great irrigation projects have recently been inaugurated, and many more are in contemplation. "While irrigation means increases and practical certainty of crops, it also means mosquitoes, and mosquitoes mean malaria. No irrigation can be carried on without creating, or at least leaving, small water holes or puddles in which mosquitoes will breed.

The farm house and the cabins for the farm hands may be well screened; this will afford some protection against malaria; but, at some time during the season, the water allotment or the condition of the crops will make it imperative for the irrigation to be done at night—and thus the protection afforded by the screening is rendered nil, as the farmhand becomes infected with malaria, which causes him to lose fifty per cent of his efficiency.

In the cultivation of rice, no artificial methods for the eradication of malaria are of any avail, as ideal conditions for the propagation of mosquitoes are created by man himself in the cultivation of that crop, thereby most effectively aiding and abetting Nature in the continuance of her schemes, which she has surrounded with immutable laws.

The preceding dissertation concludes and answers ALLEGATION TWO.

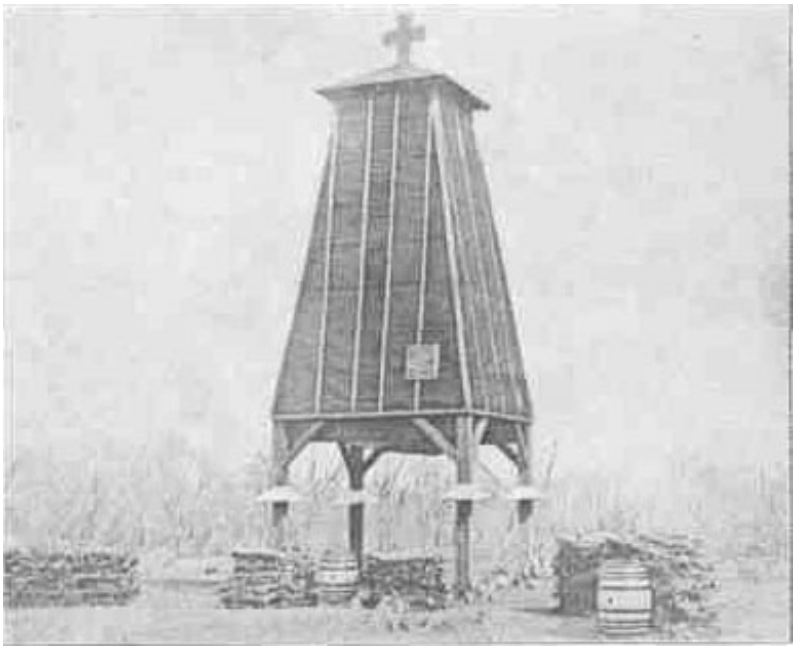
Allegation Three

That we can build a home for bats in a scientific manner to meet the requirements of their most singular habits: a home which they will inhabit and where, being protected from their enemies, they will increase in countless numbers and eradicate the malaria in the vicinities where the homes are erected.

EARLY EXPERIMENTS

When primitive man wanted sweets, he would arm himself with a stone axe, find a bee-tree, and maul it down. Doubtless he made a mess of the entire affair, and worked under great difficulties; but he got the honey. Modern man has his "bee-tree" in his back yard; he provides himself with an intricate little box, which he calls a "hive," and, without the least difficulty or any messing up of things, he gets all the honey he wants. He has learned all about the habits of this wild insect, and has provided it with a home, which can be moved about where he pleases, while the bees give him the delicious fruit of their labor.

Very many thoughts of this nature crossed the author's mind, long before this work had even a good theoretical basis. It was realized that the burning question, the great desideratum, would be (if the work were ever to be brought to a reasonable degree of perfection), "Can bats like bees be colonized and made to multiply where we want them?" If this could not be done, there would be little use in continuing a work that would represent only scientific value, when the fundamental idea was to accomplish the eradication of that world-wide disease, malaria, which Nature intended man, and man only, to carry.



Original Bat Roost.

As we are dealing with a wild creature whose home is in the mountain wilderness, miles from the haunts of man, perhaps we can provide it with a home in civilization, where we can take advantage of its wonderful habits. Oh, pshaw, this would be no feat at all! Don't we see bats coming out from behind old chimneys, from old buildings, barns, and where not? Don't they just live in any old ramshackle building? They would be only too glad to have a little home such as we provide for our song birds, swallows, etc.

These were the thoughts which, for the lack of mental gravity, or to put it in less kindly terms, because of ignorance, were put into practice, as far back as 1905, five years before sufficient information had been acquired to justify its being brought to the attention of the medical profession.

UNSUCCESSFUL COLONIZATION ATTEMPTS

Beginning with the year 1902, one bolt of cheese cloth was unfurled, placed on the floor of a large cave thickly tenanted by bats, and allowed to remain there about three months. At the end of that time it was completely covered with from four to six inches of guano, and of course saturated with the odor of that excrement. There was a dual purpose in employing the cloth; first, that it might carry the odor, and secondly that the cloth would afford a good medium for the bats to hang upon.

With this odoriferous cloth, quite a number of boxes of different sizes and construction were lined and placed on trees in different localities. Some were inserted in old buildings, some under country bridges (which are a favorite haunt for bats in the summer), and some in large warehouses and in livery stables. Others were located on large trees near a cave inhabited by millions of bats. At the author's home, in his back yard, in a very large pecan tree, a box was put, as bats were seen toward evening and at night flying around this old

monarch; also one was placed under his front gallery. These were then relegated to Father Time, and the work continued.

The boxes were substantially built to withstand the weather for several years. The second year, as much as a pound of fresh guano was added to each box, though the cheese cloth still retained its odor. The boxes all withstood the weather very well for several years, but that is about all they did do; no bat ever adopted them for a home. There was, however, one exceptional case, where two boxes were fastened to the rafters of a roof in a stable, where thousands of bats had congregated, and these boxes they entered, only because they occupied space the bats had been occupying before.

One very cold morning in January, when the bats were hibernating, one box was unfastened from the stable rafters and taken to a barn some four miles distant where the box was similarly fastened to the rafters of the barn. When the season for their flight began the following month, they left the box, and never returned. The box experiments were a most dismal failure, but as it is by the failures we make that we eventually succeed, and from the further fact that very early in the study of bats the author realized that the path to success was not "strewn with roses," he was prepared for all events, come what might, success or failure.

The failure of the box experiment appeared to indicate one of the most important features of colonization, in that bats always prefer a large building; for they will invariably occupy such a building, even if only temporarily, in preference to an adjacent smaller one. It can be readily surmised that the making of all of these experiments and observations out in the woods entailed not only a great deal of time, but considerable expense, and all of this had to come from the lucrative (?) occupation of practicing medicine for a living.

Improved Bat Roost. "My Monument."

It was beyond the author's means to erect a large building, so he called in a wealthy farmer, and explained to himthe situation as far as it then had been developed, requesting him to build such a structure on his farm, adding that if it became tenanted by bats, they would protect his family from malaria, and the guano would prove a little gold mine. This request was made to several men of wealth; in fact, the author was assuming the role of the poor inventor, with the fate that usually follows such an individual—he was turned down. The theory was fine, all admitted, but no practical results had yet been obtained.

There was nothing left for the author to do but to build a bat roost or abandon the work;—the latter was unthinkable. After months of most rigid economy, and through the aid of a good friend, the first bat roost was built at a cost of $500.00, on ground controlled by the local United States Experiment Farm. Inside were principally shelves placed at an incline for the bats to roost upon. There were also placed there three perfectly good hams with a nice slice cut out of the side of each, exhibiting their splendid quality for the delectation of the intended guests.

That they might be induced to believe that their own kind were making the roost their home, about 100 pounds of fresh guano was placed in the hopper, and about 20 yards of very odoriferous cheese cloth, which had been buried in the guano of a bat cave, was spread out on the inside and tacked on the blank wall opposite the entrance, in order to expose as much surface as possible. Several cords of mesquite wood were stacked around the roost. The mesquite tree is closely related to the tree that produces the gum Arabic, and its wood is readily attacked by all sorts of boring insects, so that bats are attracted by it and can be seen flying around and around an old mesquite pile for a long time, catching the small insects as they fly out of the wood. This feature was adopted with a view to attracting bats to the roost; also there were placed three alcohol barrels with the heads knocked out and filled with water to breed mosquitoes. This latter feature was not very long lived, as it served its purpose too well to suit the convenience of the keeper of the Farm; he proceeded to treat the uncovered surface of each water barrel with a good film of kerosene oil, thereby destroying the larvae that were developing into mosquitoes, intended to attract the bats.

As the roost had been erected on the premises only by ordinary consent, although it was an "experimental" farm, a protest would have been answered by a request to move, from which there would have been no recourse. As the owner of the roost had put into it not only his last dime, but many more dimes he had not yet earned, there was nothing left to do but to grin and bear it. However, a little experience was gained.

Another feature was added to the experiment with this roost, and that was the placing of a bright light shining on its front at night. An out-of-door lantern with a strong reflector was mounted on a post, something on the order of an old fashioned street lamp, some 50 or 60 feet away from the structure, and one of the farm hands, for a small consideration, attended to the lighting, extinguishing, filling, and general care of the lamp. This was done that the light might attract mosquitoes and other small insects to the vicinity of the roost.

In the course of a short time the experimenter saw what he thought was room for improvement in his bat roost, and having gone to so much expense already, he went deeper, to the extent of $260.00 more, making an outlay of $760.00 cash. This was in the spring of 1910, when materials and labor were very cheap. After completing the improvements, a space on the inside, 2 feet high, 2 feet wide, and 5 feet long between the shelves was walled off with bobbinet, and between four and five hundred bats were placed therein. It was hoped that the odor assisted by the light and the high squeaking of the imprisoned bats, might attract some of the nocturnal aerial passers-by of their own kind and cause them to enter where they would be so welcome. If they entered, they would surely find the juicy hams and then, having no further need for the struggle for food, would remain.

The illustration marked "Main Building Fair Grounds," was a large exhibition building employed in connection with an annual fair held in San Antonio, but unused for several years. It was on these grounds that Colonel Roosevelt recruited and organized his famous Rough Riders, the men using this building as sleeping quarters. In certain selected and isolated spots therein bats found lodgment to their liking and utilized them as roosting places. Here the observations made during the box experiments were confirmed as to the preference of bats for large and high buildings. In only a very few places and in correspondingly small numbers were the animals to be found, and then always in very high locations.

In almost all large, abandoned buildings bats will be found in great numbers for a short time only during midsummer, when they are migrating in search of food. At this time, however, they do not select hiding places, as they hang exposed from the ceilings, cross pieces, beams, etc.; but they do not remain for any length of time. From this large building towards evening the bats fairly swarmed out for two or three hours in one continuous stream. The building was kept under observation by the author and the night watchman for a number of years. It was invariably during the first week in the month of August that the bats arrived —generally about two or three o'clock in the morning. This arrival was so well timed, that it seldom passed the first week in that month. They were but temporarily sojourning in this building. The only ones that remained were those that had found suitable hiding places; and these were permanent tenants.

During the sojourn of this army of bats, a sight well worth seeing presented itself. In the auditorium hall, the ceiling, braces, and cross pieces were completely covered by their little bodies, forming one continuous mass of animated, fuzzy, squirming things. At flying time, towards evening on releasing themselves from their hanging places, they resembled tiny umbrellas being suddenly opened. Quite a number of observers have been sadly disappointed in driving out to this building to view the sight, only to find the bats gone. There was another old, abandoned, two-story building miles from this one, in which the same conditions obtained, only that in this structure there were no hiding places to the bats' liking, so not a single bat remained after the sudden departure of the colony.

Before the author interceded in behalf of these noble creatures, the officers of the fair association would drive to this building armed with shot guns and kill the bats by barrelfuls. The noise made by the guns caused a great many to escape the onslaught; and, after their enemies left, the remainder still adhered to their migratory instinct by returning and remaining until the day when the said instinct indicated that the psychological time had arrived for them to move on.

This building was about a mile from the bat roost that had just been completed and improved upon; and it occurred to the experimenter that, if they could be run out of it, some out of that huge number would find the home intended for them, in which even a larder had been provided.

But how was this to be accomplished when their roosting places were 25 or 30 feet high in the small decorative cupolas and under the arched projecting roofs, where so many of the animals were thoroughly ensconced? In attempting this eviction the good offices of the Mayor of San Antonio were enlisted; and through the Fire Chief, who placed a hose company at the disposal of the author, the work of running the bats out of the building with streams of water was begun. They were fought all day; thousands left the building, ascending very high in their accustomed manner; thousands were chased from one portion of the building, only to find lodgment in another, and be again chased out and tormented all day long. An observation of the bat roost the next evening revealed the fact that not a single bat had entered it, but a visit to the building the evening following, at the usual time for emergence, showed that the work of the tormentors had been in vain, as the bats had all returned to their places.

For months, the author with some of his friends closely observed this bat roost, particularly towards evening at what would be time for emergence, with eyes strained and riveted on the south outline of the roost, eagerly seeking the much desired sight of a fluttering little guest, who had found his man-made home. This desire was never granted. The roost, towering above the surrounding mesquite trees, 30 feet high, stood, for six years, a "monument" to the author's ignorance of the habits of bats. It was sold as old lumber for $45.00, very much to the regret of hundreds of English sparrows who considered its demolition a most cruel trespass; for had they not been in peaceful and uninterrupted possession for such a long time, raising thousands of their babies in a home no one wanted? The junk-lumber dealer, however, was inconsiderate; and the "monument" passed out of existence.

A Simultaneous Independent Effort

About this time a singular coincidence was happening many miles away. Mr. Ernest Thompson Seton, the eminent American naturalist, had become much impressed with the importance of bats, and had erected a structure intended as a home for them on an island in a lake situated in his park at Greenwich, Conn. He called it his "Tree House." Of course the author knew Mr. Seton by fame, but Mr. Seton knew nothing of either the author or the work he was doing, neither did the author know that that famous gentleman was so much interested in bats as to be attempting to do the same work that was being done in Texas. Some years after Mr. Seton finished his "Tree House" he heard of the Texas work and wrote the author a letter, which, with his permission, is here reproduced:

"I hope you have time to tell me where I can get accurate information about your battery, or bat house, which I understand is a great success. About six years ago I attempted the same thing here in Connecticut. I built a huge hollow tree, and to exclude as far as possible anything but birds and bats, I put it on an island of the lake in my park. The tree was thirty feet high, and seven feet through at the base, with many openings of different sizes, and covered with a concealed waterproof roof. Inside were many nesting boxes and other devices to invite bats, but as far as I know, never a bat went near it. It is now inhabited by flying squirrels, tree mice, woodpeckers, and wasps." Mr. Seton also has a "monument."

Main Exhibition Building.

It can readily be surmised that the author did not feel any great pride in his expensive and involuntarily-made cenotaph, for although it was empty and represented as dead all the purposes for which it was intended, it by no means contained the remains of his enthusiasm, or vehement desire to continue the work. In fact the "monument" only added to his vehemence. There was one failure, however, that did bring great joy and satisfaction, and that was the author's inability to enlist some one of wealth to build the roost for him; he had built it with his own funds, consequently had no apologies to make to any one for its failure, nor did he have to ask any one's consent to its final disposition.

For months the author racked his brain, spending many dismal days in most abject melancholy; many sleepless nights, planning, pondering, thinking, even dreaming over this most vital of all problems, colonization. With whom could he confer? Friends and fellow practitioners were as helpless as himself! Books were of no avail. What could he do? Surely there was some little path leading out of this dark labyrinth of ignorance! Was the solution to the problem that meant so much to humanity, to countless millions yet unborn, to go unsolved, and work, aspirations, and ambitions to be consigned to perpetual darkness in the fathomless sea of ignorance?

How Successful Colonization Was Achieved

There was during all this mental turmoil a little clue to which no importance whatever had been attached, but which would involuntarily bob up in the author's mind, only to be downed; it seemed to dwell in the subconscious mind, and only awaited its turn to assert itself.

The humble farm hand mentioned, who, for a small consideration, attended to lighting, extinguishing, and filling the lamp with the reflector that illuminated the front of the roost, told the author that one morning quite early, on going to extinguish the lamp, he had seen very many bats enter the roost. There was no credence whatever put in this statement, as it was believed to have been made simply from the man's desire to please the author. Besides, how could a swarm of bats ever have entered such an inviting habitation, built expressly for them, and then not want to adopt it?

This was the clue that solved the problem. It was true that the bats had entered the roost; but, finding there conditions and environments not to their liking, when they left on their evening pilgrimage they never returned. There was no room for reasoning, other than that the internal construction was not to their taste. Becoming thoroughly convinced of this, and of course intending to continue the work, the author naturally

asked himself the question—"How are we going to ascertain the likes and dislikes of such anomalous creatures?"

There was but one way of procuring that valuable information, and that was to seek and apply to the great and only infallible Bureau of Knowledge, presided over by that infallible Old Lady we choose to call Nature. As it is she who constructs and places her creatures where she chooses, if we should want to know by what rules she governs them, we must go where she has placed them, and look for her inimitable works. But the Old Lady is deaf and mute, and we shall get but little aid from her; her works and secrets are there; all we have to do is to look, and, if we are fortunate enough to be able to see, we shall find that her gorgeous handiwork permeates all the surroundings in which she intended the creature she placed there to "live, move, and have its being."

Accordingly, for a time the author suspended his professional career, closed his office, and left family and friends for the mountainous wilds of his beloved state, with a firm resolution not to return without a complete knowledge and solution of the great problem that had been the cause of so much anxiety and anguish, not to mention sleepless nights and loss of time and money. He felt sure the solution was there; it was only a question of finding it.

Without burdening the reader with the details of this expedition in quest of knowledge in which were encountered so many vicissitudes as to preclude the members of the party from being referred to as having had a "good time," it may be stated that the most salient features were these: In a region miles from water can be seen, about three miles apart, two caves, looking as much alike as two peas. One of these caves is teeming with bats, and in the other, never a bat has entered. In another cave resembling very much the two mentioned is found a deposit of guano very old, but not a single bat in it. The old guano furnishes the mute but conclusive evidence that bats had made it their home—at least for a short time. Perhaps their own cave miles away had caught fire, and they had occupied this one only temporarily. Small traces of very old guano were found in other caves, without a single bat being in them. One cave was discovered that had only recently been on fire, as it was still smouldering. Of course it contained no bats. Very many caves which, without minute investigation, resembled closely the caves they chose for habitation, although they had been in existence for countless centuries, had never been entered by bats.

It was the comparative study of the inhabited and the uninhabited caves that caused the author to become convinced that he had discovered the likes and the dislikes of these anomalous creatures regarding the architecture of their homes; so bringing the expedition to a close, he returned to San Antonio in a jubilant state of mind, eager to continue the work, and, during his journey, allowing his imagination to build all manner of bat roosts.

On this journey, what appeared as a very singular observation was made by the entire party where caves near water holes were visited, and that was that very near the mouths of the caves, mosquitoes were quite plentiful, while a hundred yards away not a mosquito was to be seen or heard. This also holds good in the vicinity of a bat roost. To the average layman unacquainted with the habits of bats, this would tend to discredit the value of that creature as a mosquito destroyer, but a little reflection will show that mosquitoes would be safer near the mouth of a cave or a few feet from a bat roost (and doubtless they know it) than a few hundred yards away. This is a matter of common knowledge among cave owners. When bats emerge from a cave or roost towards evening, they are intent on getting away from their homes as quickly as possible, in order to escape their arch enemy, the hawk; and they do not begin feeding until they are several hundred yards away. When they return home in the morning, they drop down at great velocity from a high altitude and dart into the cave as already described.

The author's eagerness and enthusiasm, however, were held in leash by a much-depleted pocket-book, which only time and close attention to business could recuperate, and this occupied several months. In the meantime, the next important move was being considered, and that was the selection of a site for the new roost. It was a matter of but little difficulty, as the conditions and environments of the selected site actually invited it. The little experience the author had gained in building a bat roost on premises by mere consent and tolerance, prompted him to use more business-like methods, and an acre was leased for a term of 25 years from the owners of the selected site, and a bat roost was built according to the new plans, scented with a quantity of an especially prepared guano which carries the sexual odor, the louvre locked, and the building dedicated to Father Time.

This structure, which the author calls his Mitchell's Lake Bat Roost, was built on the north-west shore of a large body of water, covering 900 acres of land, known as Mitchell's Lake, situated about 10 miles from San Antonio in a southerly direction. The prevailing wind, nine months in the year, is from south-east to north-west, and accordingly there would be more mosquitoes on the north-west shore, being blown there by the wind. Another reason was the proximity of an ideal mosquito-breeding place, a photograph of which is shown. This pool is formed by seepage water from the lake, covers about 6 or 8 acres, and is traversed by a paved county road. To the right of the picture is seen the earthen dam, covered by willow trees. In this pool mosquitoes bred in countless millions. Travelers crossing it on the country road were compelled to whip up their teams to escape the onslaughts of the mosquitoes, as they would run into veritable clouds of these insects. The earthen dam was built in order to raise the level of the lake. This site was selected because conditions and environments could not have been more ideal for the propagation of mosquitoes and malaria, consequently no more exacting demands could possibly be made on a bat roost in

the demonstration of the value of bats as destroyers of mosquitoes and malaria.

Into this lake, covering, as already stated, 900 acres from a few inches to twenty-five feet in depth, flows by gravity all the sewage of the City of San Antonio. (Population of San Antonio, 1920 census 161,379.) It never overflows, as the water is used for irrigation. The large amount of water left in the laterals with its huge complement of organic matter, the receding water in the lake when used freely, and particularly the big permanent pools formed by seepage through the earthern dams, outside of the main body of the lake with its dense aquatic vegetation, formed ideal conditions for the breeding of mosquitoes. No swamp in the low lands could be worse.

As an evidence of the fertility of the seepage sewer water for the growth of mosquitoes, on various occasions the surface of a quart fruit jar filled with this water, was entirely covered with mosquito eggs, as was also another jar filled with cistern water, reasonably pure. In the seepage sewer water, ALL of the eggs hatched and passed the different stages to the adult mosquito, while in the jar with the cistern water, only about half of the eggs developed into adult mosquitoes. This experiment has often been made at different times during the year.

This land is tenanted by Spanish and Mexican farmers, who live in little cabins near the shores of the lake. Before this bat-roost was built, mosquitoes bred in such numbers as actually to drive the men from the work of irrigating their crops at night, and forced them to let their crops go to ruin. At times the mosquitoes nearly covered the bodies of the work animals, which in desperation would break through the barbed wire fence to reach the higher ground. The animals rendered very poor service, indeed, being much emaciated, notwithstanding the abundance of food. The few cows owned by the tenants gave a very poor supply of milk, being likewise emaciated on account of depletion by the swarms of mosquitoes that tormented them all night long. Chickens could be heard pattering all night in their endeavors to defend themselves from the onslaughts of the mosquitoes; their combs were very pale, indicating a depletion of blood, and they correspondingly laid very few eggs, or none at all.

Hardly a family escaped the malarial infection. There had been for several years from two to four deaths annually from malaria on these lands, particularly from the malignant *type* which existed there, as well as from the other forms. During the spring and summer of 1911, the year the roost was built, the author on his self-allotted Fridays, which, as already mentioned, he had for years devoted to the outdoor study of bats in some manner, armed with a microscope and note book, made a canvass of the tenants living on the north and east sides of the lake, examining all told, 87 men, women, and children for malaria. In a very large percentage of those examined, the microscope was not necessary, as the clinical

symptoms were there to furnish their own evidence. Of these 87 people examined, 78 were infected with malaria, making it a little over 89 per cent of infection.

But let us get back to the roost which had been built according to plans furnished by the greatest and only infallible of all architects, Nature, scented, and locked on the 2nd of April, 1911, and relegated to Father Time.

Mitchell's Lake Bat Roost. Portion of Mitchell's Lake in background.

For the next three months the author did not visit this roost, not so much on account of the distance and rough roads, but because of the dire necessity of closely "sticking to his last," in order to make ends meet, a necessity which now carried the additional burden of the cost of the new roost. His absence from the roost for such a long time caused him no particular worry or anxiety, for, as might have been expected, the author had implicit faith in the construction of the roost. Faith is defined as: "A firm conviction of the truth of what is declared by another, by way either of testimony or authority, without other evidence." Who was the "another" that made the declaration and furnished the convincing testimony? There was no necessity for further evidence. The incomprehensible magician who makes everything we see, feel, hear, taste, and smell, with only a handful of her indestructible toys, the elements, gave the information, and the abiding faith followed.

A great day rolled around on the calendar; a day of rest and rejoicing for this, our glorious Nation, the Fourth day of July. The afternoon of that day was spent in quietly watching the roost from a little distance, waiting for the time bats usually emerge toward evening. At exactly 7:20 p. m., on that glorious evening a swarm of bats was seen emerging from the roost that took all of five minutes to come out. The ocular demonstration had presented itself; the goal had been reached; a modern Palladium had been created. One of the tenants who lived within 200 yards of the roost told the author he had seen

bats coming out of it towards evening, and going in again very early in the morning, for about two weeks previous to the celebration visit.

MINOR BAT ROOSTS

The photograph marked " Terrell Ranch House" is one of an old, untenanted building situated about seven miles in a southerly direction from San Antonio and about three miles from the Mitchell's Lake Bat Roost. In this old building for years large numbers of bats had congregated, but only during the summer months, after the baby bats were old enough to shift for themselves. They were certain to be there during the first week in August. The author often went there to study them, years even before the first roost was built; they were particularly thick in the ceiling of the second story and behind the chimney, which was somewhat detached from the building. This old ranch house is only a mile from the first roost built, the "monument"; and the author and his friends on several occasions had tried to dislodge them, with a view to their finding the said "monument." It was not in the least difficult to run them out with noise, hand clapping, shouting, etc., and with broom weeds tied in bundles, with which they could be swept off the ceiling without injuring them. Whenever this was done, they would ascend in their characteristic manner, and fly so high and far as to be entirely out of sight, but in an hour or two they would return. This invariably happened when they were chased out in the morning. These experiments were tried at this old ranch house, before the experiment of running bats out of the Exposition Building with the aid of the fire department. As getting them out of this old house and keeping them out by closing all of the openings was almost an impossibility, and as all kinds of tormenting were of no avail, it was given up as a bad job.

Cattle Raising on Mitchell's Lake Lands.

Terrell Ranch House.

The photograph marked "Hunting Lodge" represents a comfortable little building erected on the shores of Mitchell's Lake by a party of San Antonio sportsmen. The lake affords splendid duck shooting during the season, and this "shack," as it was named, was neatly furnished with a heating and cooking stove, kitchen utensils, clothes racks, davenports, and bunks for sleeping. In short, it was a very cozy little hunting lodge. This building is about 500 yards in a bee line from the Mitchell's Lake Bat Roost. During the summer, or out of the duck season, the "shack" remained untenanted and locked. Bats during mid-summer simply took possession of it and rendered it almost unfit for human habitation. There are other hunting lodges on the shores of the lake, but these the bats did not seem to take to. The little white squares seen under the roof are pieces of shingles which the sportsmen had tacked onto openings, with a view of keeping out the bats; but these proved quite ineffectual. The building being left entirely to itself, the bats had their own way. They roosted on the underside of the roof, and in such numbers as completely to cover not only that space, but the side walls as well. When our friends, the sportsmen, again visited their "shack" at the opening of the duck season, they found every inch of exposed surface on the floor covered with an inch of guano.

The author most ardently wished he could have spoken the bat language in order to tell the bats that a home had been provided for their especial benefit, in which all the conveniences any little bat heart could possibly desire were to be found, and that it was not very far away. This was entirely out of the question, but he knew that the odor in the roost would attract them to it if they could but be made to leave the temporary and unwelcome place they were in.

But how were we to get them out, and make them understand that they were not to come back? Did we not employ all manner of means to accomplish this, and most dismally fail? Other means, some means, had to be devised, but what could they be?

THE DELICATE SENSES OF BATS

There are other likes and dislikes about a bat besides the

architecture of its home, and these are exhibited through the most wonderful development of its auditory nerve. The author has never examined or dissected the auditory nerve of a bat, but no more convincing argument could be offered in substantiation of this assertion than that it gains its food through its sense of hearing, thereby performing the most important of all biological functions, nutrition, by that highly specialized auditory development. It means that its existence and continued existence depend on its auditory nerve.

Its hearing is adapted to detect the soft, sonorous tones made by the vibrations of the wings of mosquitoes and other small insects; and such tones it would be familiar with and find to its liking, because they are all of the same character; but there might be sound waves of the same number of vibrations as the ones it is accustomed to, but of a different character, which it might not like. Perhaps a combination of such sound waves would "be even repulsive to its delicate hearing, something on the order of the repellant effect of a grating, grinding noise, or that which the sound produced by drawing a fork at right angles over a dinner plate would have on us. If certain tones were not to its liking, they would be more repulsive to it than disagreeable noises are to us, as its auditory nerve is so infinitely-higher developed.

Following this theory, it was but natural that the "gentle art that soothes the savage breast" should present itself with its array of different instruments, each producing sound waves characteristic of itself; and the employment of the Lyric Muse was to be the next general plan of attack in the tormenting of these noble little creatures.

Of course, a brass band suggested itself, with its numerous instruments; cornets, clarionets, piccolos, saxophones, cracking trombones, producing musical sounds, and the drums and cymbals, the nerve-racking noises intermingled. Surely in this array of musical instruments there was some sound the character of which the bat did not like, and it was only the dislikes we were looking for. That the bat does not object to the soft tones of a pipe organ is evidenced by the fact that they will find lodgment in church steeples, and come into the church during services at night and fly about for quite some time, while the organ is being played. At all events, brass-band music was agreed upon.

Hunting Lodge.

Explaining this theory of sound to an enthusiastic friend who had so often joined the author in expeditions for studying bats, he most cheerfully volunteered to put the theory into practice. He was offered by the author the services of Little Joe, a diminutive Mexican boy in the author's employ, who had the agility of a cat. At home Little Joe's duties were to run errands, sweep the yard, etc., but on "batting" expeditions he sometimes became indispensable. "With the nimble-ness of a monkey, he could climb anything, anywhere, any place. If a difficult and inaccessible spot was to be investigated, Little Joe would find a way, no matter how high the bats were roosting, catch them with one hand while holding on with the other, place them in his shirt bosom, and descend with his shirt bulging with bats. This individual was the valuable assistant to the good friend.

Procuring a small wagon and a horse, a camping expedition was fitted out, to last about a week. The most important accoutrement to this expedition was a phonograph, with a loud-sounding disk, which was selected from hundreds that were heard, on account of the large number of reed instruments and some blatant high notes of cornets. The pianissimos and fortissimos also highly recommended the record. The selection was "Cascade of Roses" waltz, Victor record No. 35047-A, Police Band, City of Mexico.

The old "Ranch House" was the first selected for the "serenade;" and it was in the second story of the building that the phonograph was placed. The music was started going about four o'clock in the morning, with Little Joe as chief musician, his duty being to wind the machine, change needles, etc., and to keep the music going.

It was, indeed, a curious sight to see the bats returning from their nocturnal hunt for food about five o'clock in the morning, and dropping out of the skies, as they are wont to do, but instead of finding immediate lodgment, they would fly

around and around the house for perhaps a dozen times and then disappear. The music was kept up until the sun was quite high. The friend and Little Joe who had nothing else to do but to watch for the return of the bats, made the old Ranch House their camping place, and awaited developments, while the author returned to his "last," feeling that a small point had been scored. During the day both the lower and upper floors were swept perfectly clean of the least speck of guano, in order to facilitate subsequent observation. The bats did not return. The next morning about 4 o'clock the "concert" was again resumed, but not a single bat put in its appearance.

The friend was jubilant; he phoned in to the author the results of the morning's work, requesting suggestions for the next move. It is needless to remark that the friend's telephone conversation completely overbalanced the duty to the "last," which was thrown to the four winds; and it was not very long before friend, Little Joe, and the author were enjoying a most appetizing camp dinner together. That afternoon the Camp was moved from the Old Ranch House to the Hunting Lodge or "shack," and at 5 o'clock the phonograph was placed on the little gallery at the front entrance. No attempt in any manner was made to frighten or disturb the bats, in the least; in fact, as little noise as possible was made with that end in view.

The door to the "shack" was opened, the horn of the machine directed toward the inside, and the bats' little ears were pelted with the "Cascade of Roses." With the sound of the very first measures, a great uneasiness and shifting of the bats was observed, but with the first fortissimo, they began leaving; first in singles, then pairs, then tens and hundreds in one continual stream, until they had all left. Their time of emergence in that month, August, was always about 6:30 o'clock; now they had left one and a half hours before their accustomed time. The "concert" with Little Joe presiding was resumed the next morning about 4 o'clock, but not a single bat returned.

An inspection of the Old Ranch House that day, which it will be remembered was swept perfectly clean, showed it to be in the same condition, not a single bat having returned to it. But an observation of the bat roost, proved conclusively that they had found their newly-made home, as it took nearly two hours for them all to come out, while the colony that first found the roost took only five minutes to emerge. This demonstrated the fact that they had found the roost by the sense of smell, and conditions and environments being to their liking, they remained. The "Hunting Lodge" and the "Ranch House" have both been demolished, but for the six years that they were in existence after the "concert" experiment, not a single bat entered either of them. This the author knows, for he examined them carefully for excreta deposits, of which there were none.

A few years ago a clergyman of San Antonio established, some six or seven miles below the city, a new school at one of the old Missions, for which that locality is so noted. In order

to avoid the loss of time in making trips backward and forward to the city and school, and desiring to give the latter all of his time, he furnished for himself very comfortable quarters in an old building. Quite a colony of bats found a temporary home and lodgment between the cloth ceiling and the roof of his room. Their high squeaking voices annoyed him very much, and of course the odor of the deposited guano was exceedingly undesirable. Having heard of the "concert" experiment, for the dual purpose of amusement and battle, he purchased a phonograph and a few records. He won the battle in one day, as the bats left him to enjoy the records all to himself.

There have been made in this country and in Europe some very brilliant experiments with bats, on the remarkable faculty they possess of avoiding collisions, even in the dark. Wires were stretched across the room, and the bats, although blinded, dodged them with unerring certainty when flying backwards and forwards. It is truly remarkable how they avoid the delicate and dense limbs of brush and overhanging trees in a narrow creek, with the wind swaying the limbs. One would imagine that they would be certain to strike against some of the obstacles, or that the swaying boughs would hit them. Perhaps sound and their delicate hearing play an important role in this marvelous faculty. This peculiarity of bats has not been looked into by the author, and he leaves the solution of this one also to the conjectures of the reader.

During the next year, 1912, there was nothing new done in the work, as, when a bat roost is built, it must be left severely alone. The roost was erected in the center of the acre, which was pretty well covered with mesquite brush and prickly pear, and for two reasons it was desirable that the acre be cleared, one being for ornamentation, the other for the eradication of and protection against rattlesnakes. But this was deferred, fearing the noise made by chopping, etc., might disturb the guests in the Hotel de Bat. Prickly pears were planted in a trench dug beneath the barbed wire which enclosed the acre, with a view of having a fence of such a nature as would keep out trespassers. It is now so dense as most effectually to fulfill the intention, and in blossom time it is really a thing of beauty, with its red and yellow prickly-pear blossoms.

The next year, 1913, Father Time, with the assistance of Old Lady Nature, seemed to be working overtime, as the colony was growing wonderfully. It was during this year that the acre was cleared of all brush and prickly pear, but it was done during the winter when the bats were hibernating.

When these little bird mammals find a place suited to. their habits, they never leave it except at night to feed, returning very early in the morning. It sometimes happens that some come home quite late, but these are comparatively few; evidently they went a long way for food, and had a long way to travel back.

Some years ago, while the period of gestation in bats was

being studied by the author, occasion presented itself to catch a great many from an old building in which these creatures had found a home for many years. This was another instance where Little Joe became indispensable. Of course, as many bats as possible were caught and brought in a screened box to the author's work room in the office, and there one by one were taken out, and the sex determined. As the males served no purpose in that study, every male bat was marked by cutting a tiny "V" on the right ear, and liberated. The work room is fully three miles from the old building from which the bats were caught. In a week's time, when a large number were again caught from the same old building, in order to continue the study, some of the same ones that had been previously caught would be found, as evidenced by the mark on the right ear. These were again marked, but on the left ear, and again some caught a few weeks later. There were none marked other than twice, as it was thought that any more mutilation of their ears might interfere with their hearing, and so cause them to starve.

FOREIGN APPRECIATION

It was during this year that, thanks to the efficiency of the post office department, the author received a letter from Rome, Italy, addressed thus: "Bat Experiment Station, Texas, near Mexican frontier." As the author was the only bat experimenter in Texas, he felt that it was intended for him, so opened it. It was from the Honorable Lorenzoni, Secretary of Agriculture of His Majesty's Government, dated Rome, Italy, and stated that he had heard of the bat experiments, and requested all data on the work. There are no civilized people in the world who suffer more from malaria than do the valiant populace of that kingdom. The Government is actually in the business of manufacturing that noblest of therapeutic agents, quinine. The request was promptly complied with, and all data that had accumulated up to that time were sent to Signor Lorenzoni, with a letter under separate cover, telling him that the work was progressing most satisfactorily, and that in a few years it would demonstrate itself.

The Honorable Secretary evidently thought enough of the work to cause it to be published in the "Monthly Bulletin of the International Institute of Agriculture," of Rome,—August issue, Number 8, 1913,—in both the Italian and the English languages. As the "Monthly Bulletin" is issued by the Italian Government, it goes to the four corners of the globe; and one can imagine what publicity it received. It was this publication that caused two Austrian noblemen, representatives of their Government, to come to San Antonio for the express purpose of investigating the bat proposition. These gentlemen were so impressed with what they saw that they asked the author to make them a proposal involving his personal services in their country for one year, so that they could submit it to their Government. This was toward the end of 1913. The great war broke out the following year, which of course stopped all work of an altruistic nature.

The next year, 1914, the Roost, having attained the third year of its existence, with Father Time and the Old Lady still on the job, was beginning to give a good account of itself. The news first came from duck hunters, who reported that the mosquitoes had so diminished in numbers that they could remain in the "blinds" until dark, while formerly they had been compelled to stop shooting long before that, on account of the swarms of the insects that would swoop down on them. During the summer of that year, the author, on one of his Friday trips of observation, was approached by one of the tenants, and asked in Spanish when he was going to build another bat roost, to which he replied "What do you think of the one already built?" The man unhesitatingly answered: *"Esa casa es una maravilla."* Translated, "That house is a marvel." "If you think so well of the bat roost," continued the author, "see your neighbors and request them to make statements of their experiences of conditions on these lands, before the bat roost was built and up to the present time, reduce these to writing; and when I come again on one of my Friday trips, I will bring with me a notary public, and get them to swear to the statements so made." This was done, and the following affidavits are in the language and words of the tenants themselves. Surely these people, living on these lands year in and year out, ought to be, and are, the real judges of the value of the proposition of the cultivation of bats.

All of the following affidavits were duly sworn to by the parties named, before Albert W. Bitter, a notary public; and the translation from the Spanish is by Colonel F. A. Chapa, a Spanish scholar, who swore to them as being correctly translated, before John F. Onion, also a notary public:

PEDRO TREVINO'S STATEMENT

"Pedro Trevino, whose family consists of his wife and five children, certifies that he has lived on the Laguna lands, otherwise known as Mitchell's Lake, since the year 1904, and from that year to the year 1911 had experienced mosquitoes in such numbers, year in and year out, that he is lost for a comparison for the way in which they came. It was impossible for us to work, but our extreme necessity compelled us, and at night at times I was driven from the work of irrigating by the hordes of mosquitoes, and preferred to lose my crops rather than to stand their onslaughts.

"In the year 1908, a son of mine, 13 years of age, fell ill and was attended by two doctors who told me his fever was malarial, and if it was not broken in forty days he would not live, and he died as predicted within the mentioned time.

"From 1904 to 1911, I could not securely keep my work stock, because they would break out of the pasture to look for a place of rest, as countless millions of mosquitoes nearly covered their bodies.

"Since the appearance of the bats in this place, which was in the year 1911, we are so well pleased because we are not molested to amount to anything, for all of which we want to

thank the one who interested himself in bringing us the arch enemy of mosquitoes.

(Signed) "PEDRO TREVINO (his mark).

"Witness: Cesario Ponce."

LUCIANO GARZA'S STATEMENT

"Luciano Garza certifies that his family, consisting of his wife and four children, have lived on the lands known as Mitchell's Lake since late in the year 1908. In the years 1909 and 1910 mosquitoes were in such countless numbers that they did not permit me to work in any manner; everything for me was a hardship. Purely the dire necessity of working compelled us to come here.

"Toward the end of 1911, and the next years, 1912 and 1913, we noticed a diminution of the mosquitoes, and to that degree of being able to irrigate at night and work during the day without being molested to amount to anything.

"Referring to diseases among animals, such as chickens, we never could raise any to any degree of satisfaction, as they died on us, and those that survived had yellow combs, as the mosquitoes permitted them no rest whatever. Since the erection of the bat roost, we have had all sorts of poultry in abundance.

"Of sickness among us since 1911 to the present time we have had none at all, while formerly having had fevers nearly every year.

(Signed) "LUCIANO GARZA (his mark).

"Witness: Cesario Ponce."

SANTOS GARZA'S STATEMENT

"Santos Garza, his family comprising ten members, certifies that he has resided on the lands known as Mitchell's Lake since the year 1908, and that he has experienced a change, which he relates with pleasure. During the years 1908, 1909, and 1910, mosquitoes were so bad we could hardly enter the house during the day, and we were kept awake at night keeping the mosquito bars in place, for if there were but a small opening in the bars, there would be little or no sleep for the rest of the night, In the years 1908, 1909, and 1910, we had hardly one week's rest from attention to our sick family, suffering principally from fever. In the month of November, 1910, a girl of mine, 3 years and 3 months of age, died after lingering only six hours, medical treatment proving of no avail.

"I remember and again certify that a neighbor named Olvino, with a family of three, incautiously left one of the children unprotected by the mosquito bar, and it was so badly bitten in the face by the mosquitoes that it looked as if it had the smallpox, and it was attacked by a fever that lasted for a period of three months.

"As to my work-animals and poultry, we really counted on nothing. We lost two cows, and I judge the mosquitoes killed them, as they were never at rest, day or night.

"Since the years 1912 and 1913, and to this date, we can count on everything we have; mules, cows, and chickens. If it now becomes necessary for us to consume what we produce,

we can do so with pleasure, as formerly we could count on nothing.

"Since the years 1912 and 1913 we have not had a single case of illness; and these years have been highly productive, at least on account of the mosquitoes which came very late and in very small numbers, and which we would not feel at all. If three more bat roosts were erected on these lands, all our troubles would be absolutely ended.

(Signed) "SANTOS GARZA."

CESARIO MIRANDA TESTIFIES

"This is to certify that we, Cesario Miranda and Ramon Miranda, have lived on the lands known as Mitchell's Lake since the year 1907 up to the present time.

"During the years 1907, 1908, 1909, and 1910, mosquitoes appeared as if in clouds. In 1909 we were both very ill with malarial jaundice. In the afore-mentioned years it was a sacrifice for us to irrigate at night, and no one would help us for any amount of money. During the day it was almost impossible for us to get rest, on account of being so pestered by the mosquitoes.

"Since the bat roost was erected, which was in the year 1911, we have noticed a change year by year from the previous years.

"During the years 1912 and 1913 we were able to irrigate at night without being molested by the mosquitoes, and since 1911 we have had no illness of malarial origin.

(Signed) "CESARIO MIRANDA,
"RAMON MIRANDA."

LEANDRO LEIGA'S STATEMENT

"Leandro Leiga, whose family consists of wife and five children, certifies that he came to Mitchell's Lake lands late in the year 1908, and has resided there up to the present time.

"In the years 1909 and 1910 mosquitoes came in such colossal numbers that he could hardly find a comparison. In the years 1911, 1912, and 1913, and up to the present time, he has noticed a very decided change, year by year. In 1909 two of my horses died; they gradually dried up; we considered their deaths due to mosquitoes, as they ate well, but never took on flesh.

"As regards sickness, we remember of none, except my wife and myself had several days of fever.

"When the bats appeared on these lands, the change for us was very beneficial, because we are now not particularly molested by these insects.

(Signed) "LEANDRO LEIGA (his mark)."

MACEDONIO RAMOS' STATEMENT

"Macedonio Ramos, whose family consists of twelve children, certifies that he has lived on the Mitchell's Lake lands since the year 1910, and he passed that year amidst the greatest hardships on account of the mosquitoes, not being able to work or sleep at night. The mosquitoes came in such numbers that we feared to speak lest we swallow some of the insects.

"In the year 1911, we moved to another part of the lake, and almost opposite the bat roost, and since then we have passed happily the two years, 1912 and 1913, because we can sleep soundly in not being molested by the mosquitoes, and we have had no sickness of any kind. On the contrary, my family is enjoying good health.

"My work animals pass the days very well, and eat well. My hens fatten, and I have an abundance of chicks; I think it impossible to find a more suitable place to live than where I am, so near the bat roost.

"The owner of these lands offered me a better piece of land to work this year, but I did not want to move, neither would my family consent, as we might have to undergo the sufferings of the year 1910, or worse.

(Signed) "MACEDONIO RAMOS (his mark)."

This revolutionary change of conditions on these lands brought about by the bats, was nothing more than what was to be expected, as their numbers increased in the bat roost, for here was now their permanent home, with an abundance of their natural food close by. In fact, it was the abundance of their natural food, mosquitoes, in that vicinity that caused the bats to find the old Ranch House and the Hunting Lodge or "shack" long before the Roost was built; but their numbers never increased, as they all left during the latter part of October each year, and only returned the first week in August, the following year; while the bats in their Roost, their permanent home, began their mosquito-destroying activities, or better said, finding their food, from the 15th of February, continuing all through the year until about the middle of November, when the mosquito season closes, which also closes theirs.

There are very few artificial, or man-made things that are superior to those made by Nature, and the Bat Roost, happens to be one of them. In the man-made bat-home, the enormous loss to the progeny is entirely obviated. As already explained, the loss in their natural homes, caves, is to the baby bats that go to sleep and fall to the floor of the cave, and to the mother bats that come down after them. In the bat roost the babies can fall only to the floor of the hopper on the inside of the roost, where there are no wild animals lurking and ready to devour them. It matters not where the mother bat may be roosting in the artificial home, the baby will fall in the hopper, from which she can pick it up in perfect safety to both the baby and herself.

It has been suggested that by conserving bats they would become a nuisance in a community *by* the enormously increasing numbers, something like the pest we have in the English sparrow. This conjectured objection can be very easily answered. In the first place, bats are only too glad to have a home where conditions are to their liking, and where they will remain; unlike the English sparrow, they are all in one place, the roost; and if it ever should become advisable to kill them off, it would be an easy matter to destroy them.

It was during the year 1914 that the Medical Profession of San Antonio, as represented by the Bexar County Medical Society, again took notice of the bat work, and the following resolutions were adopted, which will speak for themselves. Below, also, is a copy of the City Ordinance passed unanimously by the City Council of the City of San Antonio, (aldermanic form of government), which was due entirely to the influence of the medical profession, some of the members of which appeared before the Council in person to urge its adoption.

It is the first law of its kind in the world.

(Copy of Minutes of Bexar County Medical Society, April 30, 1914. Dr. W. E. Luter presented the following resolution to the Society for its consideration, which was seconded by Dr. T. T. Jackson, and unanimously adopted.)

WHEREAS, on the 20th day of October A. D. 1910, at a regular meeting of the Bexar County Medical Society, Section on State Medicine, Public and Personal Hygiene, a paper was read by Dr. Chas. A. E. Campbell on the Eradication of Malaria and Mosquitoes by the Cultivation of Bats, Their Natural Enemies, and a resolution was offered and unanimously adopted, to the effect that bats should be protected by law, and

"WHEREAS, since said date a mass of evidence has been accumulated justifying the passage of said resolution, and

WHEREAS, there are so many old buildings in this city which are being demolished, and many of these bats are being destroyed, thereby destroying one of the most useful protectors of mankind. Now, therefore,

BE IT RESOLVED, that the Bexar County Medical Society request the Board of Health of the City of San Antonio to recommend to the Honorable City Council that they immediately pass an ordinance protecting bats, and that the Secretary of this Society immediately present to said Board of Health, a certified copy of this resolution.

W. H. HARGIS,
Secretary.
San Antonio, Texas, April 30, 1914.

AN ORDINANCE TO PROHIBIT THE DESTRUCTION OF BATS WITHIN THE LIMITS OF THE CITY OF SAN ANTONIO

Be it Ordained by the City Council of the City of San Antonio:

Section 1. That it shall hereafter be unlawful for any person wilfully, wantonly, or maliciously to kill any bat within the limits of the City of San Antonio.

Section. 2. Any person violating the provisions of this ordinance shall be fined in any sum not less than $5.00 nor more than $200.00 for each bat so killed.

Section 3. That this ordinance take effect and be in force

from and after its passage.

(Signed) Clinton G. Brown, Mayor. (Signed) Fred Fries, City Clerk.

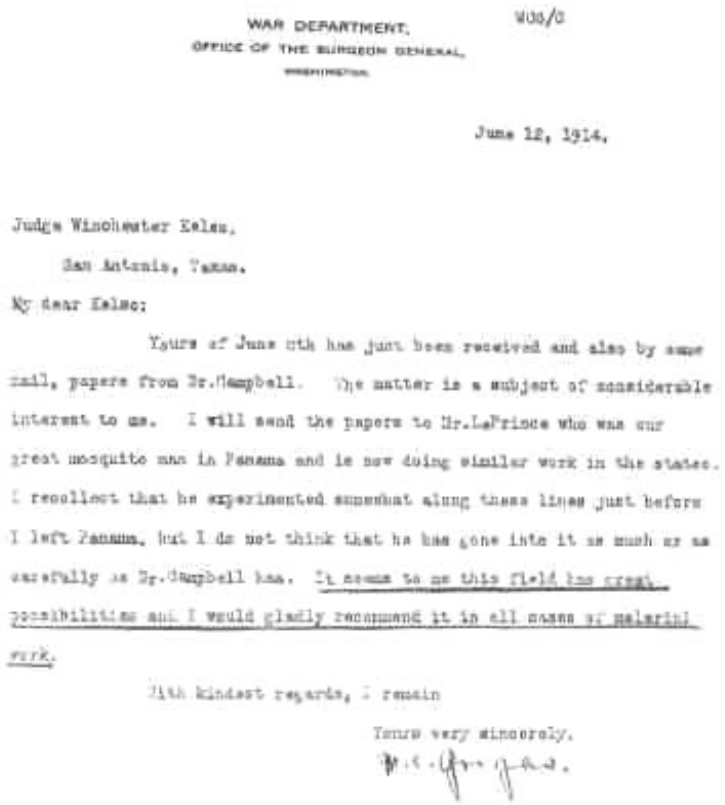
Passed June 8, 1914.

The next year, 1915, the fourth year of the existence of the Bat Roost, was indeed a memorable one. The services of Father Time, who had rendered such valuable assistance, and who seemingly had worked overtime in his endeavors to finish the work, were now beginning to come to a close. But Old Mother Nature realized that her wonderful little mammals were being better cared for in their new man-made home, for which she had furnished the plans, with the characteristics of a mother, readily gave her consent to the occupancy of the new house, in the interest of their welfare and happiness. How well these privileges were enjoyed is evidenced by the wonderfully increasing numbers, which, as if in gratitude or as a recompense for their home, converted it with their services into a Palladium, that all of the species of the builder might be protected from their enemies, as they themselves were being protected from theirs.

This year also marked a most momentous event in the entire work, as will be seen by the copy of the letter from General Gorgas, Surgeon General, United State Army, Washington, D. C., to Judge Winchester Kelso, San Antonio, Texas. The Judge being a large owner of the Mitchell's Lake lands, was desirous of having his distinguished friend's opinion on the bat proposition as a natural hygienic measure. At the Judge's request, all data on the work were forwarded to his world-famous friend at Washington. The General's reply, which will speak for itself, follows:

What were the author's feelings at reading the last sentence of General Gorgas' letter? To comprehend these, let the reader imagine himself living in a kingdom, ages ago, when "kings, the powerful of the earth," reigned supreme, and he an humble subject endeavoring for years at great sacrifice of time, toil, and hard-earned money to complete a work which he felt was destined to make his fellow subjects more happy and contented, but encountering envy, malice, and ridicule at every hand, to be suddenly rewarded by the all-powerful king in a letter in which he proclaims that he would gladly recommend the work in all cases where it is sought to be applied! Surely the king would be above all envy, jealousy, or malice, as it was only the good of his subjects that he would have at heart, and as their welfare and happiness were his. Now, let him bring that imagination down to his own time, and he will see that in reality, a modern king, greater, yes, far greater than any king, as his greatness consists in not being the son of his father, but in being a favored son of the Master who created him, and chose him to be a king of that divine faculty, INTELLECT, of which He is the sole dispenser. Yes, again contemplate, gentle reader, and your bosom must swell with pride at the proud satisfaction that this " Intellectual King," whose God-given gift of Reason benefits not a little

kingdom, but the entire world, was a red-blooded American, and a fellow-countryman of ours, the lamented General W. C. Gorgas.



WAR DEPARTMENT,
OFFICE OF THE SURGEON GENERAL,
WASHINGTON.

W36/0

June 12, 1914.

Judge Winchester Kelso,
San Antonio, Texas.

My dear Kelso:

Yours of June 6th has just been received and also by same mail, papers from Dr. Campbell. The matter is a subject of considerable interest to me. I will send the papers to Dr. LaPrince who was our great mosquito man in Panama and is now doing similar work in the states. I recollect that he experimented somewhat along these lines just before I left Panama, but I do not think that he has gone into it as much or as carefully as Dr. Campbell has. It seems to me this field has great possibilities and I would gladly recommend it in all cases of malarial work.

With kindest regards, I remain

Yours very sincerely,

W. C. Gorgas.

THE FIRST MUNICIPAL BAT ROOST

It was also during this year that the City of San Antonio, through its City Council, appropriated the necessary funds and built the Municipal Bat Roost, the first municipal construction of its kind in the world, on advice of its Board of Health, and because of General Gorgas' recommendation of the work. Of course, all of the members of San Antonio Board of Health are reputable gentlemen of the Medical profession, and being members of the Bexar County Medical Society, were thoroughly conversant with the work, but when shown the appraisal by the "World's Greatest Sanitarian," it became to them a pleasure to recommend the erection of a bat roost; and San Antonio became the pioneer in a natural hygienic and economic measure, destined eventually to prove world-wide in application. What this building has accomplished will be seen later on.

During this year the author resumed his weekly Friday visits to the Mitchell's Lake lands, and made a canvass of the north and east side of the lake, just as he had done in 1911, and not a single case of malaria was found, where formerly 89 per cent of the tenants had the disease in some form or another, and where from two to four deaths occurred yearly. There was one case brought there from Tampico, Mexico,

which will be referred to presently.

The scientific demonstration of the elimination of malaria on these lands and vicinity is nothing more than what was to be expected, after getting a good-sized colony of bats to inhabit the bat roost and make it their permanent home. As we have learned, the cycle of sporogony, which is the one that takes place in the body of the mosquito, requires from ten to fifteen days for its completion, and not until it is complete can the insect convey the parasite.

There had been ample evidence offered to demonstrate that the mosquito is the natural and principal food of the bat, and even further and very conclusive evidence that it has a selective instinct for finding the engorged mosquito. This is shown by the fact that every pound of bat guano represents more than one and fifty-eight hundredths pounds of liquid blood; it is quite natural that the newly hatched mosquitoes (which of course are not infected) that bit the carriers, were caught by the bats before the cycle of sporogony had completed itself. The bats, being very active in quest of food all night long, had from ten to fifteen nights in which to catch the would-have-been-infected mosquitoes.

The case of malaria referred to as being brought to these lands during the summer of this year afforded an excellent opportunity for witnessing a practical verification of these scientific facts, with bats in most intimate connection. A two-room cabin near the edge of Mitchell's Lake and about a half-mile from the bat roost, was occupied by a man, his wife, and his brother. The husband had just returned from Tampico, Mexico, with his bride. She had malaria in Tampico, before they were married, and continued to have it in their new home. There was no necessity of a microscopic verification of her case, because the clinical symptoms were too plain; she was having the characteristic chills. This was during the first week in June.

As decoctions of all kinds—herbs, roots, bark, etc., are favorite remedies among the poorer classes of Mexicans, the recipes doubtlessly having been handed down to them by the Indians, the author offered no objection to those therapeutic agents which were being used, when he dropped into the little cabin and saw the shivering woman. How could he? To offer modern remedies would have meant the defeat of an opportunity for scientific observation on the value of bats, as hygienic agents of the rarest kind, for which he would have given not only his last dollar, but some of his friends' dollars, to create.

The woman continued with her chills exhibiting themselves with their characteristic periodicity. It must be remembered from what we have learned, that Nature is always on duty in the interest of ALL of her creatures, and every time this woman had a chill, the gametes were evolved and found in the blood stream, thereby making her a competent "carrier," which means competent to infect mosquitoes.

One day, during the month of August, the husband, knowing the author's weekly visit was due, and that he would call on him, to show the activities of the bats in his cabin, exhibited two heaping tablespoonfuls of bat guano which he had collected in sweeping out his cabin that morning, dropped there by the bats during the night. The husband by this time was beginning to lose faith in the efficacy of his herb remedies, so the author volunteered his services, agreeing to furnish both services and medicine, gratis. This, however, was not prompted by the dictates of altruism, but from fear lest some brother doctor be called in, who would, of course, spoil the beautiful experiment by the administration of anti-periodics, which experiment for three months had been working so admirably to the credit of the bats.

It goes without saying, that the prescribed medication did not in the least interfere with the cycle of schizogony. By the middle of November, when both the mosquito season and the bat season closed, and the experiment concluded itself, this case received the most zealous care and attention in the way of proper medication, diet, etc., sparing nothing conducive to the woman's welfare, until she made a complete recovery. What did we learn from this? Notwithstanding that this woman, who was a typical malarial "carrier" from June to the middle of November, five and a half months, had lived in a little cabin with her husband and his brother, she never conveyed the disease to either of those two people, or to the people living in the near-by cabins, because the bats got the mosquitoes that bit her, before the cycle of evolution had completed itself in their bodies.

Since the publication of this bat-work (as far as it had then been completed) by the Italian Government, almost every newspaper in the civilized world made some mention of it. The London Illustrated News had a picture of the Mitchell's Lake Bat Boost, with a short description of this natural hygienic and economic measure. Two years later the Scientific American had quite an article in its issue of November 13, 1915, written by the author, at the request of the editor. All of this publicity brought the author hundreds of letters from all parts of the world, and one of the principal questions asked was," if places in the vicinity of San Antonio, or in fact, West Texas, are not better favored for the cultivation of bats than others?"

Of course, there are more bats in the neighborhood of hills and mountains, because caves are their natural homes, and these are found in such regions; but they are known to migrate hundreds of miles in search of food, and to return to their homes towards the end of the feeding season. This can be easily verified by witnessing the increasing number of bats in a cave as the close of the season approaches, and further verified by the increasing deposits of guano.

All bats that are gregarious, that is, having the habit of associating in flocks, herds, or colonies, will live in a bat roost, when they once find it. It is precisely the mission of a

bat roost to bring many squads of the humble little flying sanitary workers to the low lands and swamps, where mosquitoes and malaria reign supreme. The sole compensation for their most efficient work is a home, in return for which they render the low lands and swamps as notoriously healthy as are the regions of hills and mountains. What has been accomplished at Mitchell's Lake can with equal facility be accomplished in any part of the world.

Municipal Bat Roost, erected by the City Council of the City of San Antonio, Texas, March 17th, 1916.

The next year, 1916, the bats seemed to have doubled their population, and closer-up observations were thought advisable, in that the guests of the Palladium now considered it their home, and were not to be frightened away. Seats in the acre were provided for visitors, as well as a nice table and

bench to facilitate a luncheon toward evening, while awaiting the emergence of the bats.

STATE APPRECIATION

The Texas State Board of Health, which meets quarterly at a place and time designated by its president, the State Health Officer, held one of its meetings in San Antonio, for the express purpose of investigating the bat proposition. With the aid of lantern slides, the author presented and thoroughly explained the entire work to the gentlemen of the Board. At that meeting the author was honored by the presence of the lamented Major-General Frederick S. Funston, who became so interested in the work that he told one of his friends of the medical profession who accompanied him that he would like to see a large bat roost erected at Fort Sam Houston; that if the request for the erection of one were to be made by the medical department, he, as Commander of the Southern Department, would gladly endorse it. Because of his untimely and lamented end, his wish was never carried out.

The Texas State Board of Health is composed of reputable members of the medical profession of Texas, and what they thought of the proposition is expressed in the most flattering resolutions that follow:

STATE BOARD OF HEALTH
AUSTIN
RESOLUTIONS

The Committee offered the following Resolutions, which were unanimously adopted:

WHEREAS, the Board of Health of the State of Texas, at a meeting held in San Antonio, Texas, on August 28, 1916, heard with a great deal of satisfaction of the very original and conclusive experiments of Dr. Chas. A. R. Campbell, on "The Eradication of Malaria by the Cultivation of Bats, the Natural Enemies of Mosquitoes," and

WHEREAS, the world's greatest Sanitarian, General W. C. Gorgas, the Medical Profession of San Antonio, as well as the Government of the City of San Antonio, have given this natural hygienic measure their unqaulified endorsement, the City Government in a substantial manner by erecting one of these structures to protect its citizens, and

WHEREAS, we believe, in view of the colossal economic loss caused by malaria, that this natural hygienic measure should be encouraged not only as a state measure, but by the entire nation, and

WHEREAS, the bat has been shown to be a most valuable friend of man, it should be protected by law; Therefore, Be it Resolved, that we recommend to the Legislature the passage of a bill, making it a misdemeanor to kill a bat within the limits of this State, and

BE IT FURTHER RESOLVED that we hereby give to Dr. Chas. A. R. Campbell, our fellow Texan, our moral support and sincere thanks for his great original and thorough scientific work.

Passed by the Texas State Board of Health, August 28, 1916.

The author feels very kindly indeed to the gentleman who, of his own volition, wrote him the letter that follows, for he recognizes that it was written in a spirit of encouragement which is very acceptable; and not even having the pleasure of an acquaintance, desires by these lines very kindly to thank him. As will be seen, Mr. Gibson is a San Antonian:

1133 W. Agarita Ave.,

San Antonio, Texas.

June 27, 1916.

Dr. Chas. A. R. Campbell,
San Antonio, Texas.
Dear Sir:—

When I first came to this city several years ago and read in the newspapers the original theory you advanced regarding the extermination of mosquitoes by bats, I was highly amused, as I thought it was a well-known fact. I have since then seen several articles regarding this, and wish to say that I know from personal observation that your theory is entirely correct.

Some years ago I had a trip to make in the interior of South America. Starting from the City of La Paz in Bolivia, and proceeding by stage coach, mule-back, and native canoes or dugouts, we finally reached the small town of Trinidad, the capital of the Bolivian northern provinces. On the way down the river to Trinidad, we had to use mosquito bars on our cots every evening; for, as soon as the sun went down, the beaches where we made our nightly stops were filled by, as it seemed to me, millions of mosquitoes. Trinidad is not on the main stream, but is located on a branch some nine miles from the main river, across country. We left the canoes on the main stream, walked across to the town, and looked for a place to stop.

There were no hotels in the city, as very few travelers ever reach it, and we finally found a place in a private house where we could put our luggage and arranged to sleep outside on the gallery. When the evening arrived, I started to put up my mosquito bar, but was told by the natives that it was not needed, as there were no mosquitoes. I did not believe them at first, but after investigation and finding that no one in the town used mosquito bars, I slept without mine, and was not bothered at all by the insects. You must also note the fact that on the way down the river each Indian paddler carried his own mosquito bar, although he would go stark naked, after game, into the underbrush where a white man could not move on account of the vines and thorns. So you can readily imagine that on the river the mosquitoes were very bad.

There was only one thing that kept them out of Trinidad; and that was the enormous colony of bats that made this town their home. During the day one could hear them in the roofs of the houses, and on going, just about dusk, to see the only

church in town, a large barn-like structure, we were amazed to note the regular cloud of bats coming out of the front door. I think that my experience in that town proves without the shadow of a doubt that bats will exterminate mosquitoes in any number, provided you have sufficient bats.

(Signed) WILLIAM L. GIBSON.

Here follows another letter of similar purport from a man who studied and understood somewhat the habits of bats seven years before the author began his investigations.

Leesburg La., February 15th, 1916.
To Dr. Chas. A. E. Campbell,
San Antonio, Texas.

Dear Dr. Campbell:—

It was indeed a great pleasure to me to see your article in the Scientific American in the latter part of last year, on the eradication of malaria by the cultivation of bats. I want to congratulate you on a work that is destined to be of the greatest value to humanity.

Twenty-nine years ago the value of bats as mosquito destroyers came under my observation, and I have been observing them for that length of time in all parts of the world where I have travelled. I have written for newspapers and magazines, page after page on their great value, but always have been "turned down," the editors believing me crazy. Wherever I have lived for any length of time, I have been referred to as being "batty" or the very "batty" bat man, on account of my advocating the great value of bats.

You were very fortunate in having the backing of your profession and of your leading newspaper; and the cooperation of your fellow-townsmen speaks volumes for the enlightenment of San Antonio.

Years ago, I came to Perez, Mexico, on the Tesechoacan River in the State of Vera Cruz, where mosquitoes and malaria run rampant. The yellow fever comes there regularly, and sugar cane cannot be grown profitably on account of the cane borer. On the same river, some 25 or 30 miles further north, in the State of Oaxaca, I was told there were no mosquitoes, malaria is unknown, and yellow fever never comes there; and that not only the red cane, but also the tender white cane, is

grown, as there are no cane-borers. This I could hardly believe, so went there myself and found that what I was told was true in every particular. On investigation I found the lime-stone hills in that vicinity inhabited by millions of bats. I examined the stomachs of some of the creatures and found them to contain the remnants of mosquitoes and other night insects, the species of which I could not identify.

On another occasion I stopped and slept at a small Indian settlement on the Isthmus of Tehuantepec without a mosquito net, and found that the value of bats as mosquito exterminators was well known to the Indians. An old Cacique, or Chief, told me it was the bats that exterminated the mosquitoes. The large caves in that vicinity were teeming with them.

I could give you many more instances, which came under

my observation in my travels, of the great value of these usually-despised creatures, and now that you have discovered the architecture of the artificial homes which is to their liking, and have further demonstrated that bats, on that account, like bees, can be colonized where wanted, from actual experience and world wide travel, I am positive that you have launched a work that will be of inestimable and everlasting value to humanity, and any one who attempts to disparage it is nothing more nor less than an enemy to his fellow-man.

God bless you, and may He give you many years of good health that you may live to see your work as wide-spread as is the disease you seek to conquer.

Truly yours, (Signed)
GEO. D. COLEMAN.

The bats, having by their wonderfully increasing numbers eradicated the malaria and demonstrated the hygienic element, it was now time to give the economic element some attention, so, on December 29th, 1916, the hopper was emptied of what guano it contained, and the roost again locked.

BAT LEGISLATION

The next year, 1917, made still more history for the bat work, in that the San Antonio members of the Texas Legislature became much interested, and, on January 23rd of that year, the Hon. Edward J. Lange, Representative in the Texas House, introduced a bill making it a misdemeanor to kill or injure a bat. It passed the House unanimously; and the Hon. Carlos Bee, Senator from the San Antonio District, became sponsor for it in the Senate. In some unaccountable manner, perhaps due to the pressure of other bills previously introduced, the bill was somewhat delayed in passing the Senate. It was then that some of the big medical men of San Antonio, who are thoroughly conversant with the work and with the value of bats as hygienic agents, took a hand, and the following telegrams were sent to the Senator:

"February 20, 1917. Hon. Carlos Bee, Senate Chamber, Austin, Texas. The Texas State Board of Health honored itself by endorsing the work of our fellow practitioner and townsman on the value of bats. Put Texas in the front rank of scientific achievements by carrying out the recommendations of the Board.

(Signed) Dr. J. S. Langford."

"February 20, 1917, Hon. Carlos Bee, Senate Chamber, Austin, Texas. The passage of the bat bill makes Texas a pioneer in hygiene and preventive medicine. Get that distinction for us.

(Signed) Charles Dixon, M. D., President
of the San Antonio Board of Health."

"Hon. Carlos Bee, Senate Chamber, Austin, Texas. We look to you for the passage of the bat bill now in the Senate.

(Signed) A. C. McDaniel, M. D., President of the Bexar County Medical Society."

"February 20, 1917. Hon. Carlos Bee, Senate Chamber, Austin, Texas. I am more convinced than ever that the bat should be protected by law by all means. See that the bat bill passes.

(Signed) D. Berry, M. D., County Health Officer."

"Hon. Carlos Bee, Senate Chamber, Austin, Texas. The protection of bats originated in San Antonio. Get it for our great state. Glory enough for all.

(Signed) W. A. King, M. D., Chief Health Officer."

Slough in Mitchell's Lake; from 2 to 8 inches of standing sewer-water.

Gold pen with which the Governor of Texas signed the bat bill protecting bats.

The following is the bill as passed and now a law, Texas being as yet the only state in the Union giving to these lowly

little sanitary workers the protection they so richly deserve:

"House bill No. 40, by Lange: (In the House, January 13, 1917, read first time and referred to Committee on Criminal Jurisprudence, January 27, 1917. Read second time and ordered engrossed.) Engrossed same day. Laten Stanberry, Engrossing Clerk.

January 30, 1917, read third time and passed. Bob Barker, Chief Clerk, House of Representatives.

In the Senate — January 31, 1917, received from the House, read first time and referred to Commmittee on Criminal Jurisprudence, February 8, 1917, reported favorably."

A bill to be entitled "An act making it a misdemeanor to kill, or in any manner injure, the winged quadruped known as the common bat; repealing all laws in conflict therewith, and declaring an emergency.

Be it enacted by the Legislature of the State of Texas— Section 1. Article 887a. If any person shall wilfully kill or in any manner injure any winged quadruped known as the common bat, he shall be deemed guilty of a misdemeanor, and upon conviction shall be fined a sum of not less than five (5.00) dollars, nor more than fifteen (15.00) dollars.

Section 2. All laws and parts of laws in conflict with the above provision shall be, and the same are, hereby repealed.

Section 3. The fact that there is no law in this state protecting bats creates an emergency, and an imperative public necessity that the constitutional rule requiring bills to be read on three several days be suspended, and that this act take effect from and after its passage, and it is so enacted.

Passed the Senate on motion of the Hon. Carlos Bee, February 28, 1917.

Approved by the Governor March 10, 1917."

Col. F. A. Chapa, the Spanish scholar, and one of San Antonio's sterling citizens, mentioned as having translated the affidavits made by the tenants of Mitchell's Lake lands, is an enthusiastic admirer of the bat work. The Colonel was a member of the City Council, when the matter of building the Municipal Bat Roost came before that body; and when the bat bill passed the Senate, he, out of his high admiration for the work, purchased a gold pen and holder, journeyed to Austin, Texas, and had the Governor of Texas sign the bill with it. On his return home, with a few beautiful words he presented it to the author.

Again, the author wished he could have spoken the bat language, that he might have told the bats of their good fortune. The great law-making body of the greatest state in the Union has given them the recognition they so justly deserve, and they are not to be put to death simply because they are bats, and so badly misunderstood. No, the majesty of the law in Texas, says:" Thou shalt not kill a bat within my domain."

In one of Mr. Ernest Thompson Seton's splendid books, "Wild Animal Ways," Doubleday, Page & Co., on page 178, he pays the bat a regal tribute; and it affords the author great

pleasure to quote it: "We now know that typhoid, malaria, yellow fever, and many sorts of dreadful maladies are borne about by mosquitoes and flies. Without such virus-carriers these deadly pests would die out. And of all the creatures in the woods there is none that does more noble work for man than the skimming, fur-clad bat. Perhaps he kills a thousand insects in a night. All of these are possible plague-bearers. Some of them are surely infected and carry in their tiny, baneful bodies, the power to desolate a human home. Yes, every time a bat scoops up a flying bug, it deals a telling blow at mankind's foes. There is no creature, winged or walking, in the woods that should be better prized, protected, blessed, than this, the harmless, beautiful, beneficent bat."

WAR DEPARTMENT
OFFICE OF THE SURGEON GENERAL
WASHINGTON

January 28, 1918.

Dr. Charles A. H. Campbell,
San Antonio Academy of Medicine,
San Antonio,
Texas.

Dear Dr. Campbell:

Yours of the 21st is acknowledged

I congratulate you upon your results.

Sincerely yours,

W. C. Gorgas.

Surgeon General, U. S. Army.

Personal letter from General W. C. Gorgas.

Guano crop from Mitchell's Lake bat roost for the year 1917, 2996 pounds.

On January 2nd, 1918, the Mitchell's Lake bat-roost, which it will be remembered was emptied and locked on Dec. 29th, 1916, was again emptied, and the photograph shows the sacked guano, representing the crop of 1917, amounting to 2,996 pounds. This photograph of the 1917 crop, with the sacked guano stacked in front of the Roost, was sent to Gen. W. C. Gorgas, at Washington, D. C., in the early part of 1918, and also a letter reminding him of the assertion in the manuscript, sent him two years previously, that the proposition of the cultivation of bats had two great values, viz., hygienic and economic, and that these were inseparable. As to the hygienic element he had already said he "would gladly recommend it in all cases of malarial work;" and now he was being shown the inseparable economic element, which had demonstrated itself. The photographic copy of the General's reply speaks for itself.

This was indeed a most flattering compliment coming from the "World's Greatest Sanitarian" on a sanitary measure. The author and his friends, both lay and professional, were jubilant.

One enthusiastic friend asked for the loan of the letter, as he wished to show it to a friend of his who made quite some claims to erudition, but who was not so enthusiastic about the bat work. Throwing the letter down on his friend's desk, he said: "Read this. When a big St. Bernard like this barks, all you doubting Thomases, knockers, and canines of the Chihuahua variety ought to go way back and hide yourselves." The friend admitted he was no match for such high authority, and so fell into line.

Our great country has always been the first most liberally to respond and contribute money, clothing, food, etc., following all the world's great catastrophes; doubtless, you yourself, gentle reader, have contributed your mite, prompted by your goodness of heart, at reading of the appalling suffering. Here in our own country, going on all of the time, day in and day out, we have untold suffering and appalling economic loss, and you are asked only to lend your good words in the interest of your red-blooded American brothers who may not have the knowledge of Nature's work that you have; and you know the percentage of this class is high. It behooves us, who are a little more fortunate in the acquisition of knowledge, to constitute ourselves "our brothers' keepers" by pointing out to them the intricate schemes of Nature that are harmful to them and theirs; and, in so doing, we become worthy keepers.

No one would ever say a single word, or even make a suggestion, against this work, or ANY work, that might have the least sign of any merit directed toward the eradication of this world-wide disease, if its importance were ever brought home to him. This the author knows from actual experience in his professional life.

If you, gentle reader, have a little fellow, your own flesh and blood, whom you see beginning to lose his inclination to romp and play, his little face growing pallid, and if after weeks or months of suffering, the final tragedy is enacted, then you would see all of your fondest hopes buried in a little mound of earth, a reminder of your irreparable loss. Mental pictures of your loved one would appear to you during the day, and most vividly in home scenes in your dreams at night; would you then say one word or lift a finger against any method that might be offered to crush the monster that produced the indescribable heartaches?

There are thousands of such instances occurring in this great country of ours almost daily, directly, or indirectly caused by this colossal, hydra-headed monster, known by the familiar name of malaria.

If some of our brethren, dear readers, pooh-pooh the idea of the eradication of malaria by the cultivation of bats, it is simply because they do not understand, not that they mean to be vicious, because it is inconceivable that any man, who understands the great havoc malaria plays all over the world, should be so bereft of the milk of human kindness as in any manner to impede this life-saving, health-giving, wealth-producing beneficence.

Hygieostatic Bat Roost, the Property of the Hon. Albert Steves, ex-Mayor of the City of San Antonio, Texas.

PRIVATE AND PUBLIC BAT ROOSTS

The photograph marked "Hygiostatic Bat Roost" portrays a structure erected during 1918, being the private property of the Honorable Albert Steves, Sr., Ex-Mayor of Sac Antonio. The man and his motive for its erection give the word *humane* a practical definition. It was during this gentleman's tenure of office that the public's money was appropriated to build the Municipal Bat Roost. From the incipiency of the bat-work, Mr. Steves had been watching every move; and long ago he foresaw its value to humanity. He erected a bat roost at his country home, some fifty miles north of San Antonio, and only one mile from where he first saw the light of day. He chose to call his bat roost" Hygiostatic," coining the word from two Greek derivatives, *Hygieia,* the goddess of health, and *stasis,* standing, i. e., Standing for Health.

Mr. Steves is one of San Antonio's foremost citizens and a direct descendant of one of the sterling families that blazoned through the wilderness the paths that led to the progress, civilization, and enlightenment which the great state of Texas enjoys in this good day. Originating from the sturdy pioneer stock that "could look the whole world in the face," it was but natural that pioneer work should come to him as an inheritance, and through refinement in rearing, high educational attainments, and nobility of character; it was again but natural that his thoughts should pour out to his less fortunate brothers, and he embraced the opportunity of becoming, like his forebears, a pioneer in furthering a propaganda destined to become of such great value to humanity.

The erection of this structure was not a dire necessity, nor considered indispensable to the comforts and conveniences of the country home, as there are not myriads of mosquitoes in that vicinity. His home has all the modern conveniences that wealth can command. The commercial value, the DOLLARS in the bat proposition would appeal but little or not at all to this gentleman; but what did appeal to him was a little community of some two thousand souls, only one mile from his country home, the playground of his childhood, and this his big heart wanted to reach and benefit, when he so unostentatiously erected a Palladium for the bats.

The photograph marked "Asylum Bat Roost" illustrates a roost that is the property of the State of Texas. It was erected during 1918 on recommendation of the Superintendent, Dr. Beverly T. Young, a prominent member of the medical profession. The large building seen in the background is the Southwestern Insane Asylum. The State of Texas has four such institutions for the care of her insane; and, in the interest of those unfortunate inmates in this one, Dr. Young had the bat roost erected.

During the early part of that year, Dr. M. M. Smith of Dallas, one of the really great doctors of Texas, while in attendance at San Antonio on the State Medical Association, took advantage of his presence there to investigate the bat work. Accordingly, he and the author went over every phase of the measure, and in the afternoon journeyed to the Mitchell's Lake lands, where he saw the ideal conditions and environments for the propagation of mosquitoes, and the roost in practical operation. Dr. Smith is the editor of *Medical Insurance and Health Conservation.* How well he was impressed with what he saw is best told by the letter that follows:

September 7, 1918.
Dr. C. A. R. Campbell,
San Antonio, Texas.
Dear Dr. Campbell:

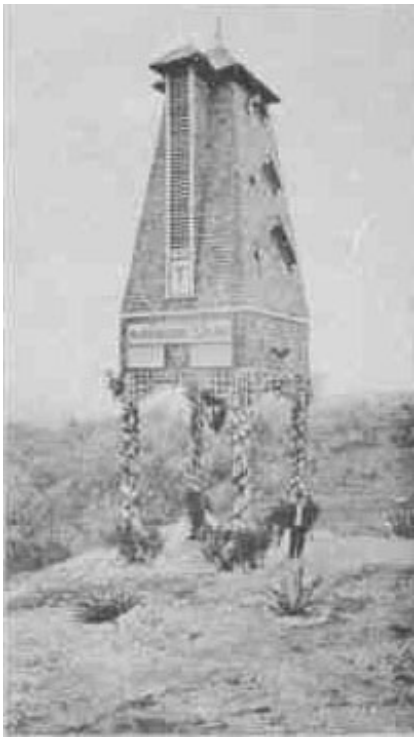
At the meeting of the Medical Section of the National Fraternal Congress of America, at Philadelphia, Pa., August 26, 1918, the following resolution, offered by Dr. M. M. Smith of Dallas, Texas, was adopted:

"RESOLVED, That we, the members of the Medical Section of the National Fraternal Congress of America, in convention assembled at Philadelphia, Pa., desire to go on record as appreciating most highly the work that has been done, scientifically and patiently, for the past seventeen years, by Dr. C. A. R. Campbell, former Health Officer of the City of San Antonio, Texas; and that we suggest to Dr. Campbell the importance of submitting in proper form, and in accordance with the rules and regulations, the subject of the bat in the destruction of malarial mosquitoes as an applicant for the Nobel Prize that is next awarded."

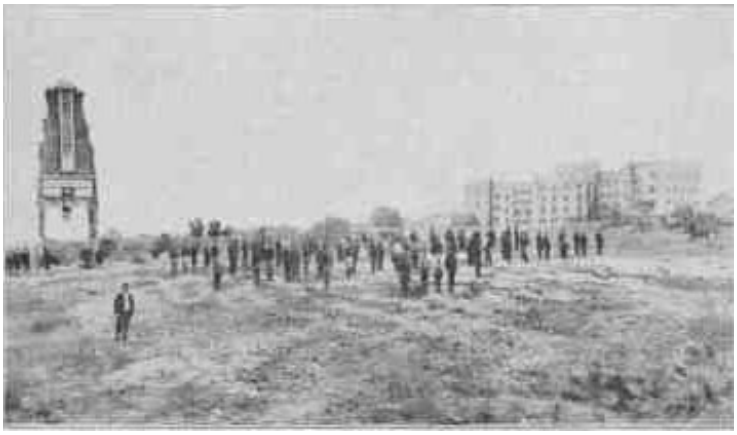
A copy of this resolution will appear in the proceedings when published.

Yours respectfully,
LULU GAY,
Official Reporter.

Erected by the State of Texas at the Southwestern Insane Asylum near San Antonio, Texas.



Dr. Campbell's Malaria-Eradicating Guano-Producing Bat Roost.



Alamo Heights Bat Roost, showing Academy in the background. Showing how close to a school or building a bat roost can be built.

During the month of May of that year Captain McKinney, Adjutant of the American Military Mission in Rome, at the instance of General Marieni, Chief of Engineers of the Italian Army, wrote to the Mayor of San Antonio for detailed information regarding the bat method of combating malaria, and this information was mailed from here by the author, to whom the matter was referred by the Mayor on June 28th. Apparently it had not yet reached Rome when the following cablegram was received July 15, 1918:

"Official Mayor, San Antonio, U. S. A.—Please send detailed information reference mosquito extermination by bats. See letter Captain McKinney, May 19. Experienced operator desired. Will pay expenses. Make proposals. (Signed) General Marieni, Chief of Engineers, Italian Army."

The ending of the war suspended the correspondence.

The author felt indeed honored when he received a pamphlet issued by the Belgian Government under the auspices of the Minister of Colonies, in which on page 91 is shown a picture of the Mitchell's Lake bat roost, and a cut of the bat guano, showing the chitinous remains of mosquitoes and other insects. The pamphlet is a very thorough publication intended for distribution to all of the Belgian Colonies, instructing their colonists as to the life and dangers of mosquitoes, and the different methods of their eradication, such as oiling, draining of land, etc. The Minister thought enough of the bat method to include it in his pamphlet. The author is unaware as to how the Minister obtained the photographs, as they were not procured from him. The pamphlet is in the French language and entitled, *"Études de Biologie Agricole,* Nov. 4, 1918."

Even our great American, the lamented Theodore Eoosevelt, was interested in this work, as shown by a letter from him on the occasion of his receiving a newspaper clipping from the author. He wrote thus:

Metropolitan,

432 Fourth Avenue, New York,

Office of Theodore Roosevelt,

December 10, 1918.

My dear Dr. Campbell:

That's most interesting. I shall read the article with very real interest.

Faithfully yours,

(Signed) T. ROOSEVELT.

The photograph of the loaded truck containing a trifle over two tons of bat guano, which represents the crop of 1918, was taken on January 12, 1919, and conclusively shows the popularity the roost had attained. Evidently its fame in bat circles, like the fame of a well conducted human hostelry had spread, so that its much desired space was permanently tenanted, not only by the first papas and mamas that found the Hotel de Bat, but also by brothers and sisters, and first cousins, second cousins, third cousins, and many cousins so far removed as to be only bats but not kin. And then hundreds living in dangerous caves, just "dropped in" or came "a-visiting," and, discovering a home so much better than the home they knew, and in which were dwelling in perfect contentment so many of their own kind, soon found friends, sweethearts, and wives, and so helped increase the colony with their babies, and their babies' babies. Had the owner known his roost was going to meet with such favor on the part of the bats, he would have made it considerably larger than he did.

RECOMMENDED BY STATE LEGISLATURE FOR THE NOBEL PRIZE

During the year 1919 the author was most signally honored by the Legislature of Texas, as will be seen by a copy of the House Concurrent Resolution No. 26, adopted by the House of Representatives on February 10th, and approved by his Excellency, the Governor, on February 18th, 1919. This, indeed, was a most flattering honor, as the author and his wife were away from Texas on a pleasure trip in Florida and Cuba during the month of February of that year, and knew nothing about the high compliment until apprised of it by wire through a good friend in San Antonio.

DEPARTMENT OF STATE
AUSTIN, TEXAS
H. C. R. No. 26.
HOUSE CONCURRENT RESOLUTION

WHEREAS, Dr. Chas. A. R. Campbell, of San Antonio,

has rendered the State of Texas and humanity valuable service in his original and conclusive experiments during the past seventeen years for the eradication of malaria by the cultivation of bats, the natural enemy of mosquitoes; and

WHEREAS, the world's greatest Sanitarian, Gen. W. C. Gorgas, the Board of Health of the State of Texas, the San Antonio Medical Society, and other sections have given this natural hygienic measure their unqualified endorsement; and

WHEREAS, the Italian Government has given special recognition to his work and distinguished service as well as other foreign countries; and,

WHEREAS, the colossal economic loss caused by malaria is sufficient to warrant the State and Nation in giving this natural hygienic measure full encouragement; therefore, be it

RESOLVED, by the House of Representatives, the Senate concurring, that the Legislature of the State of Texas, endorse the work of Dr. Chas. A. R. Campbell in his original

and thoroughly scientific work, and respectfully suggest and commend his name as worthy of the greatest reward for the service of humanity, a Nobel Prize.

E. E. THOMASON,

Speaker of the House.

W. A. JOHNSON,

President of the Senate.

I certify that H. C. B. No. 26 was adopted by the House on February 10, 1919.

T. B. REESE,

Chief Clerk of the House.

Received in the Executive Office, this 12th day of February, A. D. 1919, at 3 o'clock and 10 minutes p. m.

JOHN D. McCALL,

Private Secretary.

Approved February 18, 1919.

W. P. HOBBY, Governor.

Received in the Department of State, this 18th day of February, A. D. 1919 at 11 o'clock, and 15 minutes, a. m.

C. D. MIMS,

Acting Scretary of State.

I, C. D. MIMS, Chief Clerk, Acting Secretary of State of the State of Texas, do hereby certify that the foregoing is a true and correct copy of H. C. R. No. 26, complimenting Dr. Chas. A. R. Campbell, of San Antonio, for valuable service

rendered to humanity with the endorsements thereon, as now appears on file in this Department. IN TESTIMONY WHEREOF I have hereunto signed my name officially and caused to be impressed hereon the Seal of the State at my office in the City of Austin, Texas, this the 18th day of April, 1919.

(Signed) C. D. MIMS, Chief Clerk,

Acting Secretary of State.

During this year was also constructed the Alamo Heights Bat Roost. It was given that name on account of its being the property of the residents of Alamo Heights, who erected it by popular subscription among themselves.

Alamo Heights is the most beautiful high-class suburb of San Antonio, situated to the north of the city on hills covered with majestic oak trees and the perennial laurel, which in blossom-time fills the air with its sweet perfume. The Heights are two hundred feet higher than the center of the city and command magnificent views to the four points of the compass.

From the bottom of the rock-ribbed hills and amid wonderful natural scenery, the eye is greeted with hundreds of little crystalline springs, which, murmuring and babbling, contribute their precious liquid into larger channels, that eventually form the serpentine water-course known as the San Antonio River. It was this beautiful and natural environment that caused the pioneer Franciscan Fathers, who had blazoned their way through savage haunts and wilderness more than two hundred years ago, to halt their pilgrimage ; and this represented the birth of the Metropolis of Texas, San Antonio, the Queen City of the Empire State of Texas.

But while these good people, who represent the culture, education, and refinement of San Antonio, built this bat roost in the interest of their suburb, they never lost sight of that nobility of character born of refinement, viz., a consideration for the welfare of others, so caused the structure to be erected on the campus of the West Texas Military Academy, which is near by, in the interest of science and educational advancement.

As will be seen, the structure is more elaborate than the others that have been built, but that is only in keeping with the beautiful surroundings. The bronze caduceus, the emblem of science on the door leading to the inside of the roost, and the Lone Star, emblematic of the great State of Texas, where this measure originated, are intended to impress the young student that comes from afar to the Academy.

The writing to the left of the star is a reproduction of the second point in this work, and reads thus: "That the bat is one of man's best friends, because he so relentlessly destroys the malarial mosquito, as that insect is its natural and principal

food." "By protecting bats, you protect your fellow man." To the right of the star is a copy of the state law protecting bats.

The photograph taken on Feb. 15, 1919, on the occasion, of the completion of the structure, with the students on parade, records the inaugural ceremony.

The proposition for the cultivation of bats having now long passed the experimental stage, the two features which represent the entire gist of the work, viz., the hygienic and the commercial values, having demonstrated themselves, it affords the author great pleasure to take his friends and their friends out to Mitchell's Lake to see the bat roost and the bats emerging from it towards evening. It is felt that the bats now know that this elegant home is theirs, for no ordinary noise disturbs them. Of course, all of the bats born in the roost know no other home, hence the noise made by a small party spending the closing afternoon hours in singing, laughter, and general merry-making over a well-filled basket of the best of things for the inner man, awaiting the pleasure of the tens of thousands of these valuable little flying sanitarians to be seen leaving their home for their all-night flight in search of food, does not disturb them very much.

However, it is always best to copy as much as possible the natural solitude of the wilderness, at least for the first few years after the erection of a bat roost. The following incident clearly shows the extreme timidity of bats. A cave owner in "West Texas imagined he could improve the condition of his cave and get more bats in it by closing one small corner of the mouth by a loose rock wall. In some unaccountable manner, when the wind blew from a certain direction, there was a perfect whirlwind in the cave, and as he attributed to this the fact that his cave was not entirely filled with bats, he built a wall in one corner of the mouth, with a view of shutting off this whirlwind.

In conversation with this cave owner, the author disagreed with him as to the cause of the cave not being entirely filled with bats, and cautioned him against making any improvements, lest the bats leave the cave entirely. It yielded the owner an average of 60 tons of guano in what is termed an ordinary year; in other years, when the rainfall is excessive, and there are plenty of mosquitoes, the cave yields as much as 80 tons. In the year following the erection of the wall, which was an ordinary year, instead of getting 60 tons of guano, he only got 20 tons. It is needless to say that the "protecting wall" has been removed.

It is, indeed, most astonishing and highly gratifying to see how quickly one makes of the average layman a friend for the bat, when he is simply told that bats eat mosquitoes. "Within the last few years there were several very old buildings demolished in the march of progress in this quaint old city, and in some of these bats had found lodgment. When the work was to begin, the author would be on hand and point out to the workmen where the bats would be found, and ask them to

please not hurt these animals; that they were their friends, as they ate the malarial mosquito. A look of astonished curiosity would come over them, as if being told some joyful news; and to a man they worked with the greatest care when they found the roosting places, in order to keep from injuring them in any manner. The author did not quote to them the city ordinance or the state law protecting bats, preferring to ascertain their feelings in the matter.

APPRECIATIVE TESTIMONIALS

The photograph marked, "Hammered Copper Bat" is that of a plaque made by a French artist, Mons. A. J. Gerard, on account of his high admiration for this creature. It was presented by him to the author. It is truly a work of art. The artist took great pains in its preparation, in which he was engaged for more than a year. It is modeled from life, and made entirely with chisels and hammer, no easting or molding whatever being employed. The metal is about three-eighths of an inch in thickness. It constitutes one of the author's most treasured possessions; and, neatly framed, occupies a conspicuous place on the walls of his private office, where it receives the admiration of all who see it.

When it shall have come time for the author "to join that innumerable caravan that moves to that mysterious realm," this work of art will be removed from its neat frame on the wall, and counter-sunk into a modest piece of granite or marble which shall mark "the breathless darkness and narrow house" to which he will be consigned. And the hammered copper image with outspread wings will keep vigil over the "narrow house" in which its friend is obeying the inexorable laws of Nature. But its enduring character will permit it to show to others, to those still in the flesh, long after the friend has "gone to mix forever with the elements," that if more of these little creatures are on earth to benefit them and theirs, it is because the flying sanitary messengers had such a friend.

For some years the author has been receiving a great many letters from all over the world, asking for more information, or offering congratulatory words of praise and encouragement. The one here reproduced from South Africa is a fair sample.

UNION OF SOUTH AFRICA

Office of the UNION ENTOMOLOGIST

On His Majesty's Service

Praetoria, 23rd of August, 1920.

Dr. C. A. R. Campbell,
San Antonio Academy of Medicine,
San Antonio, Texas.

Dear Sir:

Mr. Reinhard of the Texas Agricultural Experiment Station has sent me a copy of your letter of March 13th, and also the page of the San Antonio Express of March 7th on which some bat roosts constructed on your system are pictured, and in which is an appreciative account of your work. Kindly permit me to add my homage to that of the many other public officials who recognize in your studies on bats, and in your practical application of these studies, a great boon to mankind, etc.

(Signed) C. P. LOUNSBERRY,

Chief Division of Entomology.

It would not be out of the ordinary for one to receive praise and kind words from people away from his own home, as that would harmonize entirely with the old adage of the "Prophet being not without honor, save in his own land"; but in the case of his bat roosts the author can claim, with pardonable pride, that the old order of things has been reversed.

A great many San Antonio people on their summer tours frequently discuss the bat work with fellow travellers on the Pullman cars, or at summer resorts, and the first question asked them is: "What do the doctors of San Antonio think of the proposition and its originator?" On the occasion of an extensive write-up of the bat work, published as a Sunday feature by the San Antonio Express on March 7, 1920, the reporter in gathering data, asked the author that very question, "What do the San Antonio doctors say about this?" The interviews given, by some of the prominent San Antonio physicians are reproduced with their permission, from that Sunday edition:—

"Dr. L. M. Winefield, formerly a member of the State Board of Health, in a recent interview talked enthusiastically on the subject: 'Have you seen a copy of the resolutions passed by the Texas State Board of Health? Well, that is what I think of Dr. Campbell and his work, as it was I, as a member of the Board, who introduced the resolutions

that passed without one dissenting vote. Some of the members of the Board had heard of Dr. Campbell's work, and as they wanted to know more about it, I requested the president to call a meeting in San Antonio, at which Dr. Campbell presented his work, illustrating it with numerous lantern slides. General Funston being very much interested in the subject, was also present at this meeting.

"At first glance, the cultivation of bats as a hygienic measure arouses in the average layman a feeling of derision and mental conjectures as to the sanity of the advocate; but as the work is unfurled in the consecutive steps and masterly way in which Dr. Campbell presents it, the demeanor and facial expression of the individual change to wonderment. It gives one an insight into the rare and profound thought, tireless patience, and enormous amount of the hardest kind of work involved, which, you must understand, is entirely

original.

"I have often wondered why someone had not discovered the hygienic value of the bat long ago, and put it to practical use; but I am indeed gratified and proud of the fact that fate decreed this achievement to one of our own physicians and fellow townsmen, for which he ought to receive stintless praise. Say anything kind and praising about Dr. Campbell and his work you may want to, and I will endorse it. You can't say too much."

Dr. J. S. Langford, prominent physician, has this to say:

"Dr. Campbell's valuable and original work, demonstrating the bat to be the natural enemy of the mosquito, has attracted the attention of many medical men and scientists throughout the world; and one of the best evidences of its verity is that it has the hearty endorsement of those who are closest and have watched the work, the members of his own medical society, the officials of his city, and the Legislature of his state.

"Malaria is a strong rival of tuberculosis, social diseases, and cancer in the destruction of human life; the malarial mosquito thrives nearly all over the world; Alaska and Russia are not immune; nor the coldest countries that have any warm periods. They are found in the valleys, and constitute a constant menace to health and life in many districts in the temperate zones; and in the tropics they shorten the life of the native races and quickly exterminate the newcomers. Those medical men who are engaged in microscopic blood work are often surprised to find the various forms of malarial parasites in unsuspected cases destroying the red cells one by one.

"Education of the school children and of the public, and governmental control are valuable methods of prevention of malaria by mosquito destruction, but to discover and propagate a natural enemy to consume these pests is a real benefaction of incalculable service to mankind. It is impossible to estimate the value of this form of extermination of the mosquito when the matter has been taken up and investigated and put into operation, especially in those countries where malarial disease plays such awful havoc."

Dr. Wm. E. Luter, ex-president of Bexar County Medical Society, grew pleasantly reminiscent:

"Years ago I had my office in the same building with Dr. Campbell, in fact, on the same floor; and I had occasion to observe some of his first experiments, as he often called me into his office to see any new piece of work that he had done in his studies of the bat. I became enormously interested in his investigations, because I felt he was laying down the foundation of a work that was destined to be of great value to humanity. About that time he was being criticised in a not-too-kindly manner; but that evidently made very little difference to him, as he went working on and on in that laborious, painstaking Way characteristic of the man, with a bulldog stick-to-it-ive-ness, worthy of the highest commendation, that has resulted in bringing him international fame.

"Ten years ago he appeared before the Bexar County Medical Society and presented his work as far as he had then gone with it, and with lantern slides and an array of microscopes gave his demonstrations. It was then that I, prompted by my admiration of the researches, introduced a resolution before the society endorsing the work, and that the Bexar County Medical Society give to Dr. Charles A. R. Campbell its moral support. This resolution passed unanimously, and, of course, was very gratifying to Dr. Campbell, as it meant recognition by his medical brethren and a reversal of the old adage of ' a prophet being not without honor, save in his own land.'

"I am indeed very gratified to see the wonderful progress Dr. Campbell's work has made, and now, it having passed the experimental stage, I look for it to accomplish great things; and I shall at all times be ready to give it my most hearty endorsement in the interests of humanity and of my profession."

Dr. E. H. Elmendorff, Assistant County Physician, has had wide experience in malarial cases among the country's poor. He said:

"I am only too glad to talk about Dr. Campbell and his remarkable work on the bat, as I am well acquainted with both the man and the work, and had known of his endeavors to combat malaria, long before his experiments brought such conclusive results. I am called largely in my duties as Assistant County Physician to attend the indigent Mexican population of San Antonio, where we find a great deal of malaria.

"This is but natural, owing to the habits of these people. They live in humble little homes, without screens, knowing nothing of the danger of mosquitoes; besides, in the summer time they sleep out in the open or under brush arbors, and so are freely bitten. During the cotton picking season they camp on the banks of streams or any convenient waterhole, so as to be near the water, and as the malarial mosquito is almost distinctly a rural mosquito, they return to the city infected, and with the advent of the first 'norther' the disease not only manifests itself, but the individual indefinitely becomes a 'carrier' of malaria, thereby spreading the disease.

"I was indeed gratified, even elated, when the municipal bat roost was built in that section of the city, as I felt confident that this bat roost would do for that locality what the bat roost did at Mitchell's Lake; and in this I was not in the least mistaken, as malaria has been wiped out from among the permanent residents in that section of the city, and the only agency that prevents the transients from transmitting the disease to the permanent residents is the municipal bat roost, with its large colony of bats who devour the mosquitoes that bite the transients or 'carriers' before the insects become infective. I cannot conceive of a hygienic measure of more importance than this, and certainly no health department in any community, whether large or small, is complete without bat roosts."

Average Tenant Family at Mitchell's Lake. Note healthy appearance.

This is the answer to the question most frequently asked; and it is given by the San Antonio physicians themselves.

The photograph marked "Mitchell's Lake School Children" was taken on April 12th, 1921, and shows a healthy bunch of youngsters. Nearly all are the children of the tenants of these lands, and live within two miles of the Mitchell's Lake bat roost. The principal of the school told the author that the children attended school with remarkable regularity, and that malaria among them was unknown. Their physical appearance certainly bears out that statement.

The extreme southern end of the Mission Irrigated Farms Company's property, known as the Mitchell's Lake lands, is bounded by the end of the Lake, which is near the north bank of the Medina River. Here are numerous cottages occupied by the renters of the lands of the Company, the railroad station of Cassin, the cotton gin, the school house, and the commissary.

On the south side of the Medina River are quite a number of humble dwellings of the tillers of the adjoining fields, which number justifies the existence of a prosperous general store.

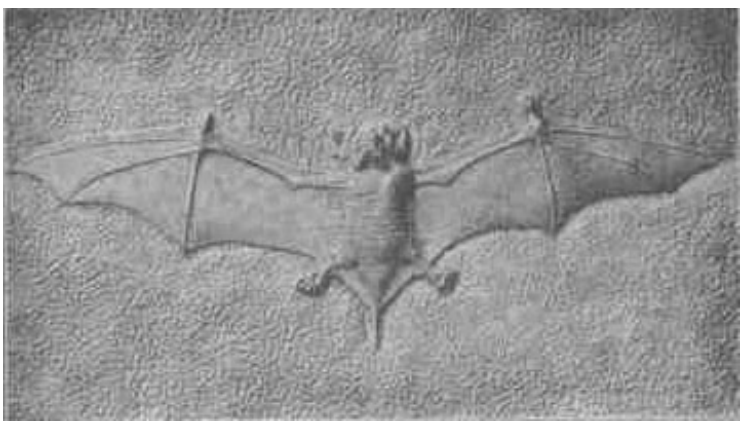
The Mitchell's Lake bat roost is about two miles from this little village, and only a few hundred yards from the lake. The general store is conducted by a merchant and his wife; and they are loud in their praises of the bat roost, which has so pleasantly changed conditions for them. In conversation recently with the author, the wife stated that when they erected their present building some eighteen years ago, mosquitoes were almost intolerable, during both day and night. They were so numerous behind the store counters as to make life miserable. There was no such thing as sitting out on

the galleries at night; and, when they lighted a lamp in the store towards evening, mosquitoes simply swarmed in, being attracted by the light.

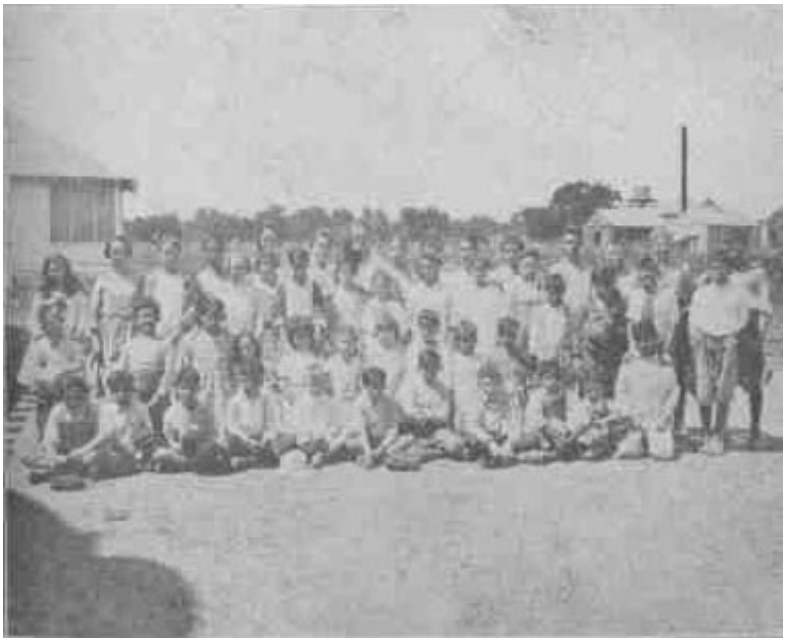
In addition to a stock of general merchandise, the store is provided with a small supply of staple patent medicines, among which was a liberal amount of malarial remedies. The lady states that formerly they purchased these in two-and-three-dozen lots, which found a ready sale; but, as time went on, the demand for them so decreased that they buy only one-quarter of a dozen vials to replenish their stock, and of these they sometimes sell an occasional bottle to some new-comer who brings the malarial infection from elsewhere. They now enjoy sitting on the galleries, the children romping and playing in the yard, and are not bothered in the least by mosquitoes.

While the statement may sound as an exaggeration or somewhat visionary, a little contemplation will soon convince the most skeptical individual that a bat roost is the most valuable thing on earth, because it saves the most precious of all things, human lives.

On September 1st, 1922, the Hon. Mayor of San Antonio, who thoroughly understood the bat proposition, on recommendation of the Chief Health Officer, attached the author to the Health Department for the express purpose of lecturing under the auspices of the Board of Health to all of the schools and colleges, public, private, Catholic, Protestant, white, and black on the value of bats as eradicators of malaria. The lectures, illustrated by numerous lantern slides, were given every afternoon in the different schools and colleges from the date of the appointment, to the end of the school term in May, 1923. Through the kindness of one of San Antonio's wealthy merchants much interested in the bat work, a prize of two dollars was offered in every school and college to the pupil writing the best composition on the lecture. The intense interest manifested by the children clearly indicates the thousands of life-long friends the little bat will have among the future citizens of San Antonio, as the lectures constituted an education given them in their tender years, the age of most ineradicable imprints.



Hammered Copper Bat.



Mitchell's Lake School Children. Note the healthy appearance of the youngsters.

The sight of a bat roost in practical operation, that is, to see the bats emerging, or better said swarming out toward evening and returning to the roost in the early morning hours, simply beggars description. This has been the unvarying and admitted experience of every one who has seen it. As an example of this, the author had considerable correspondence with a large landed corporation in Tampa, Florida, until he invited the Company to send some one to San Antonio to make a personal and thorough investigation, agreeing to give to their representative one entire day of his time. It was requested to take no one's word, not even the author's own, but to come here and see for himself. The company employed a splendid gentleman, in the person of Captain Holly S. Mason, U. S. Army, Judge Advocate's Department, Fort Sam Houston, San Antonio. The author offered this gentleman all facilities for a most searching investigation; and, on viewing the roost toward evening, he very aptly declared that no amount of explanation could adequately describe the bat roost in practical operation, for it must be seen to be comprehended and appreciated. On receipt of the Captain's report, the Company wrote for the plans and specifications, and proceeded to build a magnificent bat roost on its property in Tampa.

About the same time the author had a like experience with the Gulf & Ship Island Railroad Company of Gulfport, Miss. After extensive correspondence, the same invitation was extended the Railroad Company, to send some one to make a personal investigation, again offering to give the representative one entire day of the author's time. The

Company sent a very fine man in the person of Mr. W. P. James. He and the author went over the entire work, just as in the case of Captain Mason. This gentleman became very enthusiastic over what he saw, and readily admitted that the proposition must be seen in; order actually to understand and appreciate it. As a result of his visit, in a few days the Company wired for the plans and specifications, and a bat roost now graces the City of Gulfport, Miss.

NUMEROUS LOCATIONS SUITABLE FOR BAT ROOSTS

It might be contended that a bat roost, built at a long distance from their normal homes would not be tenanted by bats. This contention is entirely nullified when we take into account the migratory habits of these creatures. In the extreme northern parts of the United States, they would find and inhabit the roosts during the spring and summer, just as swallows find the little bird houses erected for them when they return from the south. The author would not hesitate a moment to recommend the construction of bat roosts in all low lands and swamps and also along the sea coast to the northern limits of this country, but he would hesitate in recommending their construction in mountainous regions, as ft is in such environments that their normal homes, the caves, are found, and from which they leave to migrate to the low lands, swamps, and sea coast, where mosquitoes, their natural food, are most abundant. As an evidence of this, the bat roost constructed in Gulfport, Miss., and mentioned in the preceding paragraph, is distinctly in the low lands and miles away from their natural homes; yet within twenty-four hours after the roost was finished and "scented," bats had found it; and they have made it their home ever since. The same statement holds good concerning the roost built about the same time in Tampa.

Bat Roost. Erected near Colonia Elena of the Pontini Marshes, Province of Rome, October 31, 1924.

Having learned that bats will inhabit only large buildings, even if only temporarily, a bat roost should be built of the same size as those constructed in San Antonio, or even larger, and should be placed quite high; in fact the higher a bat roost stands, the better it is to the animals' liking ; besides it protects the structure from vandals and mischievous or thoughtless boys. The Municipal Bat Boost and the Alamo Heights Roost demonstrate the wisdom of this feature.

Within the past few years the fame of the bat roost has found its way not only out of Texas into sister states, but also Europe is taking substantial notice of this natural hygienic and economic measure. As before mentioned, the Belgian Government has issued an exhaustive pamphlet on the different methods of mosquito eradication and the prevention of malaria, in which there prominently appear cuts of the Mitchell's Lake bat roost, and of the chitinous remains of mosquitoes from bat guano, as reproduced in this book. In 1922, the author was visited by a Belgian Army officer, with whom he went over the entire work; and, as a result of this gentleman's visit, the Honorable Minister of the Colonies, writes: "The researches and experience of Dr. Campbell we have followed with great interest by the competent services of our Department in Africa as well as here in Europe."

Signer Anselmo Altobelli, Italian Consul in San Antonio, took it upon himself to make a thorough investigation of the bat proposition, and he was so enthused by it that he immediately left for Italy to report on the ocular demonstration of the value of bats that he had witnessed. Lieut.-General Giovanni, Chief of Engineers of the Italian Army, has undertaken the task of introducing this natural

hygienic and economic measure in his country and its colonies. Under date of November 30th, 1924, the General writes and 'encloses photographs of two bat roosts that have been built In Italy, one erected near Colonia Elena in the Pontine Marshes, the other in Terracina in the Province of Rome. Some time later the General wrote for three boxes of "bait" one for each of the roosts already built, and one for a bat roost ordered by the Italian War Department. On March 12th, 1925, the three boxes were shipped to him as shown in the photograph taken on board an Italian Steamship at Galveston, Texas. Still later, the General requested three more boxes, saying the War Department would build another roost, and that the Navy Department would build two at Brindisi. These boxes of "bait" also have been shipped to him. Imagine the SERVICE this one man will be able to render to his country, its people, and its agriculture, when the same two powerful agencies, viz., Old Dame Nature and Father Time, take possession of the Italian Roosts as they did with the Mitchell's Lake bat roost, and which they are sure to do! It will involve the elimination of the untold tribute which that valiant country pays annually to malaria. As already stated, the site of the Mitchell's Lake bat roost was selected because of existing conditions and environments for the propagation of mosquitoes, as no more exacting demands could possibly be made on a bat roost than those found there. They were there-long before the bat roost was built, and they are there to this day. In the year 1902, this lake was an insignificant body of water in the center of a very wide and deep vale. This was prepared to receive all of the sewage of the City of San Antonio, by building earthen dikes in suitable places. The topography of the land lent itself most admirably to this purpose, as the lake is 130 feet lower than the centre of the city. At that time a 30-inch outfall-sewer amply sufficed, but in 1914, a 60-inch one became necessary on account of the increase in population, so that now both the 30-inch and the 60-inch sewer pipes pour all of their contents into an open ditch, and this sewage finds its way by gravity into Mitchell's Lake. Conditions for mosquito propagation have not changed one iota since 1902, except to be made more favorable by reason of the increased volume of sewage and the correspondingly larger area of water in the lake.

Bat Roost. Erected on property of Signer Ugo Natali in Terracina, Province of Rome, October 31, 1924.

In 1911, the year the Mitchell's Lake bat roost was built, the President of the land company, as if to add burdens of proof for the roost to assume, threw an earthen dam across a wide and deep slough several hundred yards from the lake, intending to impound rain-water for the domestic use of his tenants. Had the gentleman given the projected building of this lake the proper consideration before contracting for its construction, it would not have been built. The water in this lake is not used for domestic purposes, as water fowl, wild ducks and water hens, contaminate it, when they fly freely back and forth from the large sewer lake. But the impounded rain-water, particularly the large pools of stagnant water created by seepage through the earthen dam, afford ideal conditions for the breeding of mosquitoes, and this has been going on ever since the dam was built.

"That virtue has its own reward" is a very old and true proverb, though it sometimes travels at a snail's pace; but the little bats will get their reward, because their virtue, their great good, was given to them by Old Mother Nature, and we know she never makes mistakes. They have many, many friends in San Antonio, where they have been rewarded for the benefit they confer. They expect only a home, and that has been given to them. But when it is sought elsewhere, away from their friends, to describe their virtues, in order that their great services may be widely known, they meet the adverse influence of ignorance, malice, envy, and prejudice. Nature has endowed them with habits that bring to us incomparable good that cannot be changed by pernicious voice or

slanderous pen. They retain the superlative nobility which enrolls them among the first of Man's Best Friends.

There are other well-known artificial methods of combating malaria, and not for one moment would the author attempt to disparage any of them. We know that some of them are really effective, but are we going to rely upon and advocate one method only, be it oiling, draining, top-water minnows, bats, or what not, because we know it to be effective? That would be as ridiculous and nonsensical as it would have been for our high military authorities to send only our infantry to conquer the enemy in the World's War, because they knew that branch of the military service was really effective. Nay, we should, figuratively speaking, adopt infantry, cavalry, artillery, machine-guns, poison gas, bombs, mines, aeroplanes, or any other diabolical method ever employed successfully in the slaying of our fellow beings, towards conquering this hydra-headed monster, malaria, that slays more human beings and brings more suffering and misery than all the wars that have been fought on this mundane sphere of ours have ever caused.

Drainage, if done in a thoroughly workmanlike manner leaving no depressions for water to stand in, is the most effective method of eradicating the transmitting agent of malaria, as it abolishes the breeding place of mosquitoes; but even then, eternal vigilance, is the price of continued success. Unfortunately, in some instances this cannot be done, as the expense would be too great.

The oiling of standing water, such as ponds, pools, ditches, etc., where mosquitoes are breeding, is another very effective method, as the film of oil on the water drowns the mosquito which is in the water in the larval and pupal stage (wiggler and tumbler). In both of these stages, the mosquitoes require air, and as they come to the surface of the water to breathe, they encounter the film of oil, which their delicate breathing-tubes cannot penetrate; hence they drown. It often happens that, after oiling the desired places, a heavy downpour of rain will wash away the oil, and then the adult mosquito has again her breeding grounds all to herself. This calls for another oiling, with its concomitant expense, which oiling must be kept up and done thoroughly every ten or twelve days, or before the new crop of mosquitoes hatches out, until the end of the mosquito season. That this effective method is unreliable, if not carried out with the most rigid precision, is shown by a series of experiments which the author conducted some years ago; they are given herein, as they may prove of interest to persons engaged in the praiseworthy work of eradicating mosquitoes.

Three boxes of "bait" consigned to General Marini on board Italian S.S. *Nicola-Odero,* March 12, 1925. Captain, Steamship Agent, Chief Officer, Italian Consul, Chief Engineer, and Author.

As the argument and the subject involved are quite lengthy and entirely irrelevant to ALLEGATION THREE, the reader will be introduced to a good friend in the insect world, who is and always has been of inestimable value to all of us. The introduction will be found in the succeeding part of this book, under the title of "OBSERVATIONS ON DRAGON FLIES."

The author has watched the malarial situation at Mitchell's Lake for the last six years very very carefully, making a canvass of the district every two or three months, freely mingling with the people that occupy that former malarial hole; and he wishes to state, with all the vehemence at his command, that malaria has been eradicated from these lands, and that the eradication has been brought about solely by the cultivation of that transcendent little creature, the bat. These are the practical results obtained; and it is results that count.

The proposition of the cultivation of bats for their hygienic and commercial value having long passed the acid test of time, every community, large and small, should have one or more of these structures as part of its sanitary equipment. The first cost is the only cost, as a bat roost carries no overhead expense, and if properly built, will last for one Hundred years, continually exhibiting its two values, the commercial one paying handsome dividends on the investment.

A bat roost of the size of those shown in the several cuts, which have been built in San Antonio, will cost from twenty-five hundred to thirty-five hundred dollars, according to how fancy or pretentious it is desired to make it. The external construction can be made very ornamental; but, of course, there is to be no deviation in the plans of the internal construction, which are very complicated, and which, as has already been stated, were furnished by the only infallible architect, Old Dame Nature.

What has been accomplished by the cultivation of bats at

Mitchell's Lake, can, with equal facility, be accomplished in any part of the world. If this natural hygienic and economic measure, unaided by any of the other well-known methods of malaria eradication, can banish malaria from such environments as those Mitchell's Lake presents, with its intake of the entire sewage of the City of San Antonio, some 15,000,000 gallons daily, how much more certain can we be in ridding any community of malaria, if assisted by some of the artificial methods!

The cost of conducting the sanitary department of any community for the protection of the public health entails one continued expenditure of public funds; and the contagious and infectious diseases are, of course, of the most vital concern. The proposition of the cultivation of bats, places this natural hygienic and economic measure, which concerns itself in the eradication of the most prevalent of these diseases, in a class distinctly by itself; and when its cost is compared with the other necessary expenditures for the protection of public property, the result gives to the statesman and the sanitarian an unassailable argument for its wide-spread adoption.

From the San Antonio Fire Department, the information is obtained that one of the up-to-date fire-fighting apparatuses, costs $11,000, and requires a day and a night shift, of twelve men each, for its operation. The wages of these men amount to $15,000 a year, and the cost of repairs, fuel, oil, tires, etc., comes to about $300.00 more. In ten years the apparatus and its operation will have cost $164,000, and the said apparatus will either have suffered a deterioration of 8 per cent annually or become obsolete, while a bat roost costing from $2,500 to $3,500 to build, and nothing to operate, at the end of ten years, instead of becoming obsolete or being taxed with a deterioration of 8 per cent, is in the very height of its usefulness hygienically and paying from 5 to 10 per cent on its original cost, moreover, it will continue doing so indefinitely.

The preceding dissertation concludes and answers ALLEGATION THREE.

Allegation Four

> That each bat roost, in addition to its great hygienic value, is in itself a little gold mine, by reason of the cash obtained from the natural high-grade fertilizer, the guano, which it will constantly produce.

What would the reader think, if he were asked to invest in a gold mine from which all of the ore had been taken out, and, at the end of a year, it had all replaced itself? What would he think, if he had, attached to his mercantile establishment, a warehouse in which, as fast as the goods were removed for display and sale, they would replace themselves without the expenditure on his part of one grain of energy or one cent in money!

In the first place, no such thoughts would ever enter a normal man's mind, but if such questions were asked, the listener would forget the questions and think only of and pity the questioner, concluding that the insane-asylum authorities had been derelict in their duties.

And suppose it should be further stated, that, in addition to being made the recipient of free new goods that would yield him large profit, he would be doing the noblest of all deeds, helping his fellow man! Helping his neighbors and their little children for miles around to be more happy and contented! He would now not merely think, but would firmly conclude, that the insane-asylum authorities had lost their star boarder, and that he had found him.

While these statements, measured by a sound, practical, business mind, appear idiotic, they nevertheless describe the true conditions an owner experiences when he acquires a bat roost, or a bat cave which he works for commercial purposes, because he becomes associated with, depends entirely upon, and relegates his enterprise to an associate, who furnishes to the enterprise her most wonderful creation. Failure in association with an infallible associate is, of course, entirely out of thought, hence what appears as so extraordinary, so idiotic, becomes an actuality. That infallible associate is Old Lady Nature.

HARVESTING GUANO

The bat-cave owner removes tons of bat guano from his cave during the winter, and never gives the place another

thought until he returns the following year with his "cave men" and equipment, ready to remove the new tons which have been replaced by the Infallible Associate.

The term "cave men" is a trade name peculiar to the business of harvesting the bat guano, and does not mean the wooly, ante-diluvian, hide-covered, long-haired missing-link we see in pictures emerging from a cave with a club and looking for trouble. Going into a bat cave is like going into an ice factory in which the ammonia pipes are leaking badly. The crew that usually is employed in gathering this valuable fertilizer is composed of men accustomed to doing this kind of work. It is truly remarkable how long these men can exist in an atmosphere in which the oxygen is almost replaced by the ammoniacal gases constantly generated by the decomposing guano, and by the fresh gases liberated while overturning the guano and sacking it.

The cave owner knows better than to take with him at harvesting time a crew of inexperienced men, as they would either throw up the job or emerge from the cave every little while for fresh air. As the caves are usually miles from the railroad, he provides himself with experienced hands, who, technically, are referred to as "cave men." The harvesting of the guano is usually done in the winter, because the natural heat of summer is greatly increased by the chemical heat generated by the decomposing guano; besides, the work in the cave at this time disturbs the bats least, as they are then hibernating.

A bat-roost owner offers to his associate superior inducements, which result in great good to both owner and associate. He, therefore, enjoys a pronounced advantage over the cave-owner who cannot tender these inducements, but must accept the association on terms offered by the associate. We will refer to this matter a little later.

There are many caves in Texas inhabited by bats, ideally situated, that have no commercial value on account of the caves leaking, so that after protracted rains the nitrogen is leached out of the guano, which thus loses its commercial value. Other caves that do not have these serious defects are situated in such inaccessible places in the mountains, and so far from the railroad, that the cost of building wagon roads to reach them is entirely prohibitive.

The enormous mouths, or entrances, to some caves render their commercial value almost nil, on account of the facility with which moisture enters the cave. On foggy mornings the side walls of the caves fairly drip with moisture, which, of course, leaches out the nitrogen. Through some caves pass underground streams; in others, springs are found, both producing evaporation that keeps the guano moist, and the same undesirable conditions obtain as those in a large-mouthed cave.

One of the most conclusive and uncontradictable arguments

in support of the assertion that it is precisely the mission of the bat roost to eliminate malaria and mosquitoes in the low lands and swamps, where they reign supreme, is the fact that in certain enormous caves, from one of which as much as ten carloads of bat guano have been removed and sold, there is not now a single bat. An example of this is seen in a cave in Brewster County, Texas, some 110 miles from the railroad on the bluffs of the Rio Grande on the American side of the river.

At best the rainfall in this region is exceedingly slight, and in the last few years there has been no rain at all. The cave owners in that portion of Texas report that the bats have nearly all left on account of the climate being too dry, and accordingly no mosquitoes. Perhaps, when the seasons change and the rainfall increases, the caves in that region will again become tenanted.

Within a radius of 150 miles from San Antonio, particularly to the north and west, are some quite productive bat caves that have been emptied annually for many years; and the owners enjoy a permanent and dependable source of revenue from them. There is a cave only 27 miles northwest from San Antonio that has been worked since the year 1856. The owner, who owns also another cave, sometime ago wrote the author a letter in which he says:

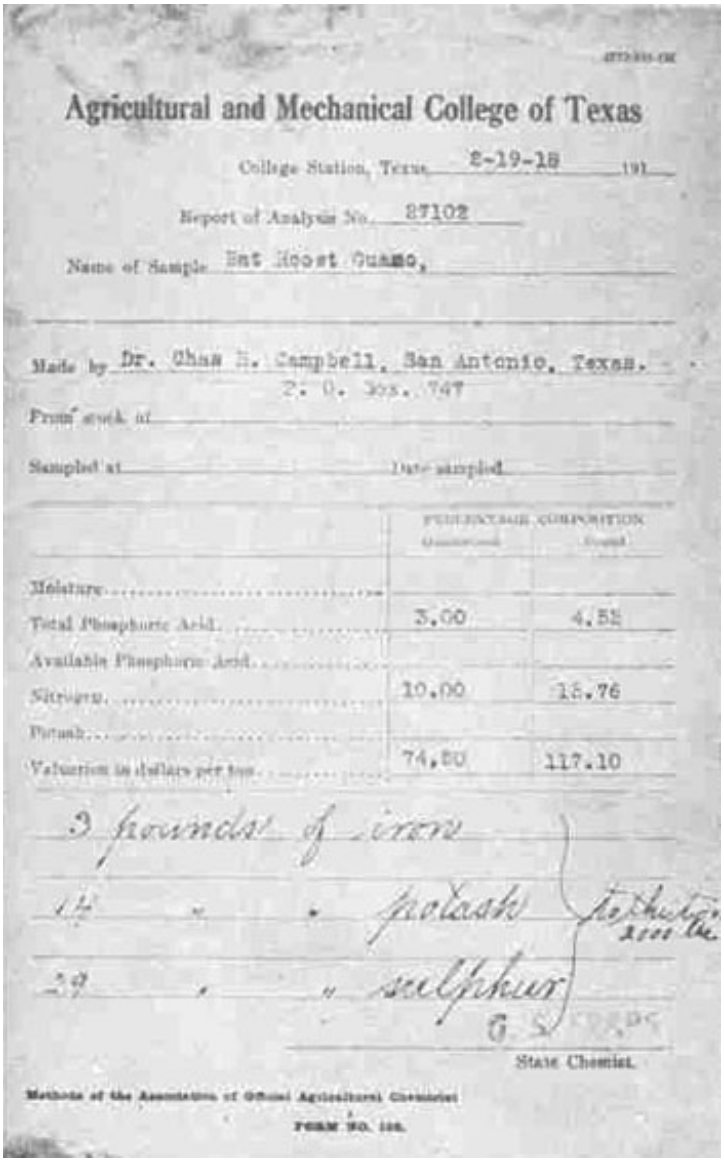
"I work two bat caves, one 19 miles from Sabinal, the other seven miles from here (Bracken). They are known as the Cibolo cave and the Frio cave. The Frio cave is a very large one, and yields about 80 tons of guano annually, but I lose about 20 tons on account of its enormous size and some colossal boulders, which prevent gathering all of the deposit. The Cibolo cave yields on an average of 75 tons annually; it is much smaller than the Frio cave, the bats are not so scattered, and I have a smaller area to work. I have, however, the same trouble in this cave that I do in the other, viz., large rocks which prevent me from gathering the entire deposit. However, in a wet year, when all water holes are full, and there is plenty of water, I count on a heavy car load more from each cave. You know the reason why. I make large shipments to Crystal Springs, Jackson, and Hazelhurst, Miss., though sometimes I have shipped the entire crop of my Cibolo cave to Laredo, Texas, on account of an extensive onion industry developed there."

COMMERCIAL FACTORS OF GUANO SALES

Bat guano, like ore, is sold entirely by analysis, the nitrogen and phosphoric acid being the most valuable commercial constituents. It contains also three pounds of iron (as shown in the "Functions of the Spleen"), 14 pounds of potash, and 29 pounds of sulphur to the ton. These three constituents have no commercial value *per se,* but they are of great value to the guano, as they are of such a chemical nature as to be known, as "available;" that is, they are fit food for plant life, without undergoing further chemical changes—

most important of all, they are in the proper proportions. Milk is the ideal food for mammalian life, not only because it contains all of the elements of nutrition, but because it contains them in the proper proportions placed there, in that manner, by the only infallible chemist, Old Dame Nature. In bat guano, she distributes the iron, potash, and sulphur in those exact proportions that make it as ideal a food for plant life as is milk for the human.

Nitrogen has sold as high as $8.25 per unit, and phosphoric acid as high as $3.25 per unit. . In order to protect the agriculturist or truck farmer, the law in Texas compels all dealers in fertilizers to have their product analyzed, and to attach to each bag a printed tag, furnished by the State Chemist, stating the guaranteed percentage of both nitrogen and phosphoric acid. The fertilizer may contain more of each than the guarantee calls for, and the dealer will be paid for the full amount it contains, but he must attach a guaranteed amount of both these chemical constitutents. The wisdom of the law is quite obvious. The buyer is protected from being sold bat guano of an inferior quality, which would be such as gathered from a leaky cave, and in which all of the nitrogen would be leached out.



Agricultural and Mechanical College of Texas

College Station, Texas 8-19-18 191

Report of Analysis No. 27102

Name of Sample Bat Roost Guano,

Made by Dr. Chas H. Campbell, San Antonio, Texas.
P. O. Box. 747

From stock of

Sampled at Date sampled

	PERCENTAGE COMPOSITION	
	Guaranteed	Found
Moisture		
Total Phosphoric Acid	3.00	4.55
Available Phosphoric Acid		
Nitrogen	10.00	15.76
Potash		
Valuation in dollars per ton	74.50	117.10

3 pounds of iron
1½ " " potash
2½ " " sulphur

State Chemist.

Methods of the Association of Official Agricultural Chemists

FORM NO. 105.

Chemical Analysis of Mitchell's Lake Bat Guano.

It is in very dry caves, only, that the best guano is found These caves are quite scarce and very valuable. The largest percentages from a really valuable cave will reach as high as 8 per cent of nitrogen and 4 per cent of phosphoric acid. Where the caves are easily accessible, even if the percentages of nitrogen and phosphoric acid in the guano are only one-half of those in the output of the best caves, it nevertheless pays to, work such deposits, because the "associate" has furnished them gratis, and as the guano costs the cave-owner nothing.

There have been quite a number of people in this country, Cuba, and Mexico badly "stung" by going into the bat-cave business without any previous knowledge or experience in that branch of commercial pursuits. In contemplating the purchase of a bat-cave or its contents, the prospective investor should exercise great caution before he makes what appears to be a most alluring investment, as he might be sinking his money in one of the undesirable caves already described.

The bat-cave owners of Texas who work their caves, usually have their regular buyers, and to these they ship

annually their entire crop. In the large cattle ranches of West Texas are some caves that could be harvested to good advantage; but the cattleman is content with the raising of his cattle, and doesn't bother about bat caves.

If an association, organized on the basis and following the plans of the wonderfully-successful fruit-selling associations of California, would take hold of the bat guano of Texas, millions of pounds of this valuable fertilizer could be placed on the market, and the soil of this great commonwealth would Be wonderfully enriched.

During the war, when the question of food became a burning one, the author, desiring to do his "bit," organized the Texas Bat-Cave-Owners' Association, with a view of introducing this Nature's fertilizer into general use. It was attended by 18 or 20 interested cave owners. Officers were elected, by-laws adopted, etc., but, as the war ended, interest in the Association slackened, and it now only awaits some guiding hand to place it in the important economic position where it so deservedly belongs.

The officials of the Southern Pacific Railroad Company estimate the bat guano handled annually over their road out of Texas at fifty carloads of 30,000 pounds per car. From the territory northwest of San Antonio, it is estimated that 15 carloads are shipped out, making a total of 65 carloads of this valuable fertilizer produced in West and Northwest Texas annually.

MILITARY USES OF BAT GUANO

It is not only man in quest of gold and Nature's creatures in quest of food, that invade the solitude and disturb the serenity of the wilderness homes of this noble creature. Mars savagely takes possession; and the ennobling pursuit of enriching the soil, thereby bringing happiness and plenty, at his dictation is converted into the demoniacal making of gun powder that brings death and desolation.

In the early "Sixties" when the war lord blew his pestilential breath over this beautiful country, and the fraticidal struggle followed, he caused these noble creatures to become his valuable allies. The Confederacy, finding its ports effectively blockaded, particularly in the latter part of 1863, established a powder factory a few miles below San Antonio; and the powder's most valuable ingredient, saltpeter, was made from bat guano gathered from the nearest caves, from 30 to 60 miles distant. Huge hoppers were made of cypress lumber hewn from trees close by, or from large flag stones, and were erected on streams or water holes nearest the eaves being worked. The guano was brought in wagon loads or in sacks to the hopper, in which it was put in layers alternating with wood ashes, the said layers being separated by strata of broom weeds. As the water which was then poured into it gradually filtered through, it was put into a

series of large, open, cast-iron boilers, which were fired; and when the liquid was reduced to the proper specific gravity, it was conducted into large shallow pans, where the saltpeter crystallized by evaporation, and was sacked and shipped by ox-team to the factory, miles away.

It is most interesting to hear the story of making saltpeter from the bat guano as told by one of the actors in that drama. They worked with oxen and burros, neither of which they were compelled to feed, because the soil furnished their fodder in abundance. They made a wagon road to the cave where that was possible, or a trail in the mountains for the sure-footed burros. The burros were trained to go into a cave with a rawhide box strapped on each side, and when these were loaded, to return to the wagon, or to continue through winding mountain passes to the hopper to be relieved of their loads, and then to return to the cave.

The favorite cave among these workers was the Verdi Cave, having a mouth large enough to permit a four-yoke team of oxen to be driven inside and the wagon loaded and turned around, with plenty of room to spare. Many were the vicissitudes endured; and an ever-ready and open eye for marauders and red-skins made self-preservation the main concern of those obeying the brutal calls of the war lord, who had this beautiful land in his remorseless grip.

ADVANTAGES OF THE ARTIFICIAL HOME FOR BATS

In the arguments offered for the demonstration of ALLEGATION THREE, it stated that a bat roost, which is man-made, is one of the few artificial things that are superior to the natural. Also, in one of the preceding paragraphs it is stated that the bat-roost owner "offers the associate superior inducements, which result in great good to both owner and associate, and a pronounced advantage over the cave owner," etc. What does he offer ?

A strong, well built, truncated structure that will last for generations, constructed on plans furnished by the associate, to which are added features greatly enhancing the association. Its shape and elevation from the ground make it singularly resistant to high winds and storms and depredations. During the summer of 1914 a terrific hurricane struck the Mitchell's Lake bat roost from the Northwest with such force as fairly to churn the water in the lake, but without as much as budging the structure.

The "tragedies" mentioned as occurring in a bat cave, where so many baby bats and their mothers fall a prey to wild animals, cannot occur in a bat roost, as, no matter what place the mother bat might select for herself in the roost, when her baby falls from her embrace, it will drop into the huge hopper in the bottom of the structure, where it is perfectly safe from any enemy, as is also the mother when she flies down to the hopper after it. This feature conserves the lives of both, and as

this indicated saving can be multiplied by tens of thousands, the value is quite patent, when we consider that each bat will, at a conservative estimate, deposit in one year 624 grains of guano.

Another very valuable feature of a bat-roost is shown by the photostatic copy of a certificate of analysis from the State Chemist, which demonstrates a strong point in the commercial element of the cultivation of bats, again affirming the assertion that the man-made home of a bat is superior to the natural. It was stated that many bat caves are valueless on account of moisture sufficient to leach out the nitrogen, also that some caves are in entirely inaccessible places, and that eight per cent is the highest nitrogen-content the best cave-guano produces.

We erect our man-made bat-home where we please; and, as we build it perfectly water-tight, the guano cannot be deteriorated by moisture. An analysis of it shows almost double the nitrogen content of the best cave-guano, and it correspondingly brings more than double the cave-guano price, on account of being bone dry, so that there is no moisture to pay for.

The nitrogen content in a bat roost can be further increased, if after each accumulation of 4 or 5 inches of guano, the surface of the deposit is covered with a thin layer of any ferruginous earth or clay, which is to be found almost anywhere. These layers of earth would, to a great extent, prevent the escape of the constantly-generating ammonia. Of course this would not permit of the self-generating, ammonium sulphate feature, presently to be described.

All of this valuable material, it matters not where the bat may be roosting, falls into the hopper, with attached chute, which is provided for just this purpose at the base of the structure. This chute, similar to those for filling sacks in a flour mill, is in the middle and on the outside of the roost. Unlike a bat cave that has to be emptied by severe hand labor during the winter on account of the heat and to avoid disturbing the bats, it can be automatically emptied at any time, or only as much guano taken out as is desired, leaving the balance thereof in the roost, which serves most admirably as a warehouse.

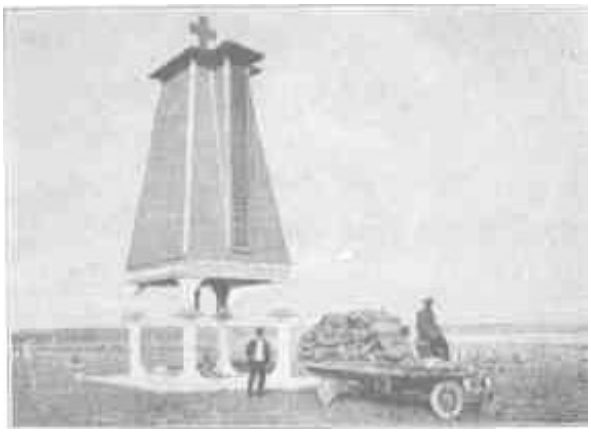
Owing to the peculiar and intricate construction of the bat roost, a space of about three feet by ten feet at the base on two sides is unavoidably formed, which, so far as serving the bats to any purpose is concerned, might be referred to as "lost space"; but the owner, knowing some of the ways of his powerful and infallible associate, now assigns to her another duty which she gladly accepts, and proceeds to add laurels to the man-made home of her most wonderful creation. This new duty involves chemical affinity. Well fitting doors in two of the outside walls help form the triangular "lost space," which is provided with a perforated wooden floor. In this space are placed suitable shallow boxes lined with sheet lead, or coated

inside with hot wax, and filled with commercial sulphuric acid. The perforated wooden floor allows the constantly-generating ammoniacal gases to enter the "lost space." This gas, which costs nothing, and which would otherwise be lost, combines with the sulphuric acid, costing 3 or 4 cents a pound, and converts it in the shallow boxes into ammonium sulphate that sells for *16 or* 18 cents a pound. This chemical product is a highly-prized fertilizer, and is also used in the arts and in medicine.

COMMERCIAL VALUE OF BAT GUANO

It was during the year 1921, that bats fairly swarmed to the Mitchell Lake lands. The Mitchell's Lake bat roost was simply choked with these creatures. They even clung to the underside of the projecting roof; on the inside they clung to one another in huge bunches. Two small cabins near the lake, that did not happen to be tenanted, were alive with bats. In the ten years that the author had been carefully observing these creatures, he had never seen them in such numbers. The bats in the cabins did not stay long; but those in the roost remained until the end of the season, and perhaps would have become permanent tenants, if they could have found the necessary accommodations. As a result of these innumerable visitors to the Mitchell's Lake bat roost, the guano crop of that year exceeded that of any previous year, amounting to 4,558 pounds. This was a most extra'ordinary migration; as, for the next two years, the roost settled down to its average production of approximately two tons per annum.

During the last six years the author has sold all of the valuable fertilizer produced by his Mitchell's Lake bat roost in lots of one thousand pounds to florists, and in smaller quantities to private individuals for pot plants, lawns, etc., at very remunerative prices. While his family enjoys a nice little bit of "pin-money," with which many small wants may be satisfied, the real enjoyment and proud satisfaction he experiences are due to the good the bat roost has accomplished for others. This is evidenced by the smiling, contented, chubby faces of the healthy school children at Mitchell's Lake, who live within the influence of the bat roost, and who are kept in a most desirable condition of health by those transcendent little creatures and the infallible "associate."



Hauling the 1918 crop to market—4012 pounds. Mitchell's Lake Bat Roost.

Guano crop for the year 1921, 4558 pounds.

"My Back Yard." Fertilized by original method.

It seems almost unbelievable that such a small structure produces such a large amount of the most valuable of fertilizers; and, as the hygienic element is so familiar to thousands of San Antonions, the author was desirous of exhibiting the commercial element to some of his friends. To that end, during the early part of January, 1924, the 1923 crop, just as it had been deposited by the bats during the year and amounting to approximately two tons, was viewed in the

hopper of the Mitchell's Lake bat roost, by Mr. Ernest Steves, President of the Alamo National Bank, Mr. Ernest Brown, Vice-President of the same institution, Hon. Augustus McClosky, County Judge of Bexar County, Mr. Geo. D. Armisted, a writer representing the San Antonio Express, Dr. S. P. Cunningham, President of the Bexar County Medical Society, Mr. W. G. Higgens, Vice-President of the International Lions Club, Mr. Prank G. Huntress, General Manager of the San Antonio Express, and Mr. Albert Steves, capitalist and President of the San Antonio Chamber of Commerce. These gentlemen were astounded and highly pleased with what they saw, and were loud in their encomiums for the little bat and his man-made home.

During the summer of 1901, the author and an esteemed friend of his, equipped with a farm wagon, a good team, and a well-filled grub-box, made a lengthy camping trip into the highlands of West Texas, travelling leisurely along mountain streams, continually inquiring as to the location of bat caves, which were the primary incentive of the trip. On one occasion upon being told by an old settler about where a large bat cave was to be found near a clear-flowing mountain stream with an abundance of water and perhaps some fishing, the campers, without the slightest hesitation, made for and found the place as described. The cave is indeed in a very inaccessible locality, requiring almost the agility of experienced mountaineers to reach it.

INSPIRATION AND RESULTS

This was the first large bat-cave with its millions of tenants and thousands of tons of guano that the campers had ever seen; and the feelings and emotions aroused by the sight in the cave, and by the emergence of the bats towards evening, simply cannot be described. It was during the summer of that year, and in the august presence of that cave, that the author firmly resolved to make the study of these creatures his life's work.

The idea of the cultivation of bats was not a spontaneous one at that time, as that had been in mind and some work had been done thereon two years previously; but it was the inspiring sight of this large bat-cave in all its pristine force that furnished the enduring impulse to maintain unswerving efforts despite endless difficulties and hardships and unnumbered discouragements, with which the reader is by now pretty well acquainted. The author was then in the same position that any investigator will be in if he or she endeavors to solve the splendid problem outlined in "Dragon Flies," and undertakes to make those insects subservient to the welfare of mankind.

The reader has been told of the many years it has taken to complete this work, and he has also been shown that it is now possible, as demonstrated by practical application, to have the valuable fertilizer, bat-guano, instead of being deposited in a

cave in the mountains, and there go to waste, be deposited in a bat-roost on the plantation or farm of our cultivated lands, there to enrich twice or thrice the earth that furnishes us our nourishment, giving to the tiller of the soil a three-fold recompense—health, happiness, and wealth.

Pecan Tree four and a half years old, fertilized with bat guano.

Every single pound of guano that a bat-roost produces enriches the soil and makes it yield bountiful crops. The two tons of bat guano the Mitchell's Lake bat-roost produces every year, and which are all utilized, mean two tons that have not gone to waste.

A bat-roost which will last for a century on the farm, means the accumulation of Nature's fertilizer free of cost; even to the sacking, which would be quite unnecessary, as only as much as is required for immediate use on the said farm need be taken out at a time. Thus there will be saved the cost of the sacks, the labor of sacking the guano at the cave, the hauling of the filled sacks to the railroad, the paying of freight on the cave guano, and on some 15 percent of moisture that it contains, and the profit to the middle man.

HORTICULTURAL APPLICATION OF GUANO

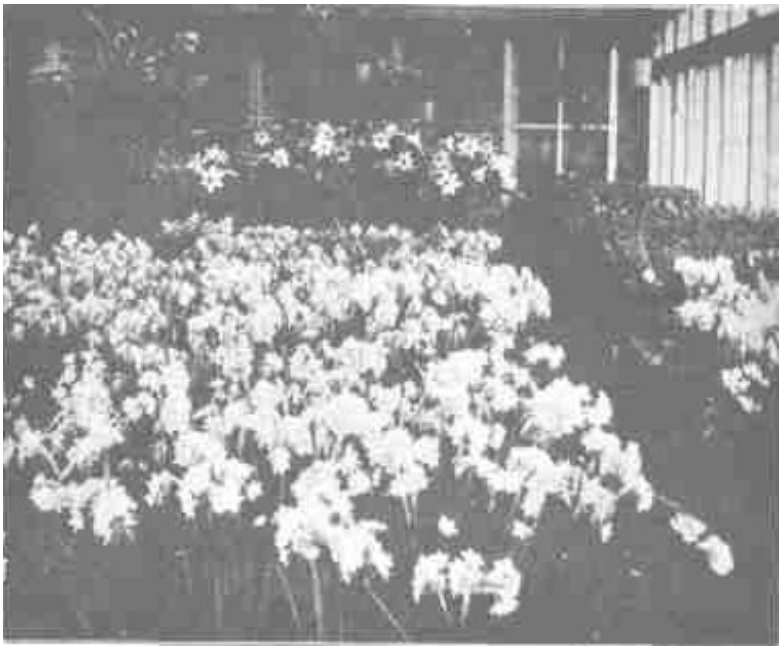
The photograph marked "My Back Yard" shows what can

be done with this natural fertilizer; and, from results obtained, the method employed recommends itself particularly to the orchardist. In this instance, the guano was not mixed with the earth around the vine and spaded under, but was buried in the ground. A hole about two feet deep is dug at least five feet from the tree or vine, and a trench of the same depth and about 8 inches wide is excavated from the hole to the said tree or vine. In the hole are placed about 20 pounds of guano; then both hole and trench are refilled with earth. The object of digging the trench from hole to tree is simply to loosen the earth so as to facilitate the roots' finding the guano, which they will do with unerring certainty by sending an individual branch to the guano and covering it with thousands of little rootlets to carry the nutritive material to the mother vine or tree.

The pecan tree shown in the cut, was planted on Thanksgiving Day, 1920, when it was one and one-quarter inches in circumference and stood thirty-nine inches above the ground. In four and a half years it has grown to a height of 22 feet and 6 inches; and the circumference at 39 inches from the ground is just twelve inches. The first year, though it was well provided with healthy and uninjured roots, very little increment was noticed; but, about the middle of the second year, it took on a luxurious growth, with shining dark green leaves in abundance; and the increase since, as can be seen, is most remarkable. It is quite patent that it had simply obeyed the laws governing its kingdom, and that the loosened ground afforded it the facility of doing so, which meant the finding of its natural food that stimulated the luxuriant "growth which indicates its perfect nutrition. It now comes into foliage two weeks ahead of the wild pecan trees.

By this method of fertilizing a protracted rain does not put the nitrogen in solution and wash it away, but it remains in the ground and becomes at all times available to the plant. This kind of fertilization needs to be repeated but once in five or six years, as the tree or vine has been provided with a larder that will last that length of time, or, in mining terms, it has been "grub-staked."

But it is not only the orchardist, who brings us delicious fruit, that the bat through its guano serves so admirably ; it also serves the florist, who brings us his beautiful flowers,—God's mute but eloquent poems which gladden our souls and enable us to pour out our emotion, the gentlest feelings of our hearts, in alleviating the woes of others with silenced lips.



San Antonio-grown Hyacinths and Narcissi fertilized with Mitchell's Lake bat roost guano.

San Antonio-grown Carnations fertilized with bat guano from Mitchell's Lake bat roost.

The photographs marked "San Antonio Raised Flowers" are a striking illustration of the nourishment this natural plant-food furnishes, as these were all fertilized by pure bat guano. The superior quality and matchless beauty of the carnations, sweet peas, Easter lilies, narcissi, and hyacinths show for themselves; and if these flowers could speak, their little voices, as delicate as the flowers are sweet, would rise in one dulcet chorus offering thanks to their enterprising owner for having provided them with the food their Master intended they should have.

By no means does the author think that the resolution he made in the wilds of Texas 24 years ago has been carried out to completion, for the study of bats is unquestionably an unbounded field. The work, however, as originally projected, is, to all intents and purposes completed; but for this achievement the author neither claims, nor is entitled to, credit or praise, as it was not completed by him, but, as often before stated, by the most powerful of all agencies, Old Dame Nature assisted by Father Time. It is the work of these two masters that the author desires the world to see; and, to that end, a most cordial invitation is extended to any one desirous of investigating. The author will take great pleasure in showing him or her all courtesies, and will provide all facilities for the most searching investigation. Everything is as wide open as Nature herself; there is nothing to conceal. The best and most crucial time for such an investigation is during the height of the mosquito season in August and September.

In conclusion, and as a résumé of the entire dissertation, it may be said that the bat catches and eats that most malevolent of insects, the malarial mosquito, and then, as if to punish it for its malevolency, converts the insoluble remnants of its little poison-carrying body into the highest of fertilizer, the guano, thereby enabling us to make four blades of grass grow where only one grew before.

PART II

Observations on Dragon Flies

MAN'S BEST FRIENDS IN THE INSECT WORLD

The primary object in adding these studies to this book, is to introduce the reader to another of Nature's creatures, a formidable enemy of the mosquito, which, could we enlist it in our campaigns, would make possible a 24-hour-a-day war by its natural enemies against that most baneful of creatures. As we have learned, we have, in the nocturnal twelve hours, a powerful ally against the night variety of mosquitoes. We have also a powerful ally for the diurnal twelve hours against the day variety, if we but study its habits, and cause it to be of service to us. This ally is known as the Dragon Fly, the Mosquito Hawk, or the Devil's Darning Needle. To realize that this service can be effected, we have but to contemplate to what a high state of cultivation man has brought one of Nature's wild insects, the honey bee.

That the propagation of the Dragon Fly will involve the hardest kind of work, and will often meet with dismal and disheartening failures, goes without saying; but the labor involved will not be as hard as the bat work was, because, dealing with a daylight creature, the studies can be carried on during the day, while the bat work had to be done principally at night.

SUGGESTED OCCUPATION FOR WOMEN

As our American women are more and more creditably filling important roles in every-day affairs, it has occurred to the author, that, if some lady enthusiast, desiring to be of real value to her fellow-beings and to do something fundamentally different from women's ordinary pursuits, would take up this work, she would find an ideal out-door recreation in an unexplored field; in fact the daintiness of the work and the beauty of the insect itself suggest its being in dainty hands; besides, what a thing of beauty a collection of these varicolored insects would be! It ought particularly to appeal to our young ladies of wealth, as its performance would take both time and money. No particular training or specializing in any branch of science would be required; all that would be necessary would be infinite patience, a little common sense, and the natural ability of being able to SEE, when one looks.

In order to assist some fellow-worker in these studies, the

author presents these data, carried on almost up to the time of closing this manuscript, for he feels they would materially assist such a worker. The investigator will find herself placed on her mettle; and if with initiative and concentration she succeed in verifying by experiment one little thought of her own creation, she will enjoy satisfaction incomparable.

We have seen how the most dismal, long, hard, expensive experimentation was necessary to bring the wild and timid bat from its home in the mountain wilderness, without in the least subduing it from its state of Nature, to a home in civilization. So we may expect to encounter difficulties in the breeding of this beautiful and most valuable insect near our homes, in public parks, open places, or, better still, on our own lawns. Then they will clean up our diurnal mosquitoes, thereby providing for a twenty-four-hour-a-day warfare waged against that most malevolent of insects, the mosquito; by the bat at night, by the dragon fly during the day.

This is the goal that the student must set for herself. How can it be won?

CHARACTERISTICS OF THE DRAGON FLY

Dragon flies are known in various localities by different names; "snake feeders," "snake doctors," "Devil's darning needles," "mosquito hawks," and various other appellations indicating that something of superstition surrounds their existence. The study of the different species of these insects and their habits is indeed most interesting. There are many hundreds of kinds, found all over the world; and, geologically speaking, they are of most ancient origin. Fossil specimens of enormous size have been found in the lithographic limestone at Solenhofen, Germany, in deposits of Jurassic age. Some of the specimens are more than eight inches in width. When we consider the size of the present-day mosquito which serves the present-day dragon fly as food, we can draw a vivid mental picture of the size of the mosquito that served as food for the monster dragon fly of that period, nine million years ago.

To observe this creature emerging from the larva into adult life is indeed a marvelous sight. From the sluggish, ugly chitinous box, our eyes behold the development of a strong, daring, and combative creature, which in a few minutes of oxidation acquires beautiful and varied colors, and is ready to justify its existence. Darwin has termed it "The tyrant of the insect world."

The student of these creatures will not be long in concluding that they are "One of man's best friends in the insect world," though in their own world they are indeed tyrants. Some years ago, and again only very recently, the author in studying them observed a dragon fly capture and completely devour the thorax and abdomen of a large wasp. What dexterity and valor it must display to conquer such an

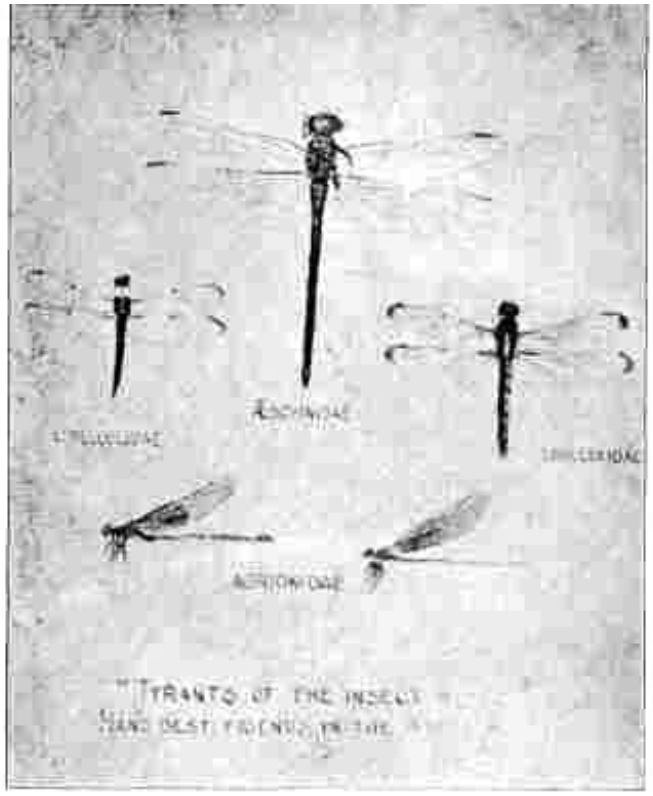
insect armed with such a formidable lancet fully competent to penetrate any portion of its delicate body! In the many years the author has been observing these beautiful creatures he has never seen a bird capture a single specimen; perhaps the birds indigenous to the San Antonio climate do not eat them.

ENEMIES OF THE DRAGON FLY

Spiders that weave wide and vertical webs along river banks capture quite a number of them, and then they become perfectly helpless on account of their hooked legs and large, webbed wings.

Every experienced fisherman has witnessed a trout leaping out of the water to capture a dragon fly as it glided gracefully over the surface of the water. But the escaped insect will take no more chances in flying over that particular pond or body of water, because when thus struck at, it will ascend vertically in the air like a wild duck that has been shot at, and will continue its hunt for food at some other pond or water hole.

Perhaps the beautiful and variegated color of this creature is a Nature's scheme that they may serve as food for large frogs, for bull-frogs can be seen to leap after and capture these flies on the wing. A small frog, waiting motionless for hours on some tiny eminence in an open place on the edge of a pond or pool, may appear to be just resting, or taking a sun bath; but, if we exhibit the same patience in watching him, we shall ascertain his real object. The smaller varieties of dragon flies (agrionidae) also seek some little eminence for observation, and this the tiny frogs seem to know, and they counterfeit the ground to such perfection that the dragon fly will alight on the frog's nose, when it is immediately snapped up and swallowed.



Dragon Fly Guano; showing skeletal remains of insects, principally mosquitos.

FEEDING HABITS OF THE DRAGON FLY

The large species (libellulidae) will usually select the tip of some dry exposed limb extending over the water or very near it, and adopt it as an observation point. It is interesting to watch them turn their heads, which are nearly all eyes, at each passing object, darting after it and returning to its post smacking its lips as it were, but again turning its head almost completely around at some passing flying thing. Ifwe throw a small stone within a few feet of it, it will turn its head almost

completely around, as if to focus all of its many lenses on one concentration point. The largest varieties, if captured by hand, will bite hard enough to be distinctly felt.

The author and some of his friends have often witnessed the value of these insects as destroyers of mosquitoes at Mitchell's Lake. On one edge thereof bull-rushes grow luxuriantly; and toward evening dragon flies have been observed to come there and hover over these aquatic plants, darting after and capturing the emerging mosquitoes and describing one continuous ellipse, until darkness compelled them to go to roost.

The appetite of the dragon fly for the common house-fly is apparently insatiable. At a beautiful pool fed by a clear stream, near the headwaters of the San Antonio River, two of these lordly beauties flew around and around, darting here and there, then disappearing for a time, only to return shortly and resume their former dartings. The author stationed himself near their accustomed paths, caught a common house-fly, and tied to one of its legs a very thin bright-red silk thread, then allowed it to fly away. Being burdened with the weight of the silk thread, it flew slowly away, and had gone only a few feet, when one of the dragon flies turned like a flash, caught it, and, perching on a nearby limb, proceeded to devour it, which it did in an incredibly short time, the dropping of the red silk thread indicating the disappearing of the victim. This experiment was repeated so often that the author, tired of catching flies, left the place, feeling that these useful and beautiful creatures should be given a name more commensurate with the good done by them.

BREEDING OF THE DRAGON FLY

Both the dragon fly and the mosquito breed in water; and the dragon fly usually remains close to the place where it was hatched, as it is there that it finds its food. It does wander from one pool to another, as can be observed from the fact that at certain hours of the day a pool may be entirely free of dragon flies, and again hundreds can be seen hovering over the same pool a little later on. The small varieties (agrionidae) seldom venture far from their breeding places. The large varieties (libellulidae) have been observed by the author, gliding over dusty country roads, in the pursuit of their food as much as four or five miles from the nearest water, and even roosting or resting on the ground. This would indicate that small insects, other than aquatic ones, constitute some of their prey, or, perhaps, the aquatic insects becoming scarce at their accustomed places, they wander away from such localities to hunt for food.

BREEDING GROUNDS AND FEEDING GROUNDS

The source of one of the most beautiful rivers in Texas is a large lake, which, on being dammed for the water-power it

affords, left a large slough where the depth of the water ranges from a few inches to several feet. The slough is out of the deep, swift current in the lake, and affords ideal conditions for the propagation of floating water-plants; and these, with the algae, formed excellent breeding grounds for mosquitoes. During the day hardly a single dragon fly can be seen, but toward evening, they visit the slough in countless thousands, flying backwards and forwards over the plant-covered surface of the water, and catching the mosquitoes, which were then beginning their nocturnal flight, until darkness precluded further observation.

Mosquito breeding hole. Standing seepage sewer water at Mitchell's Lake.

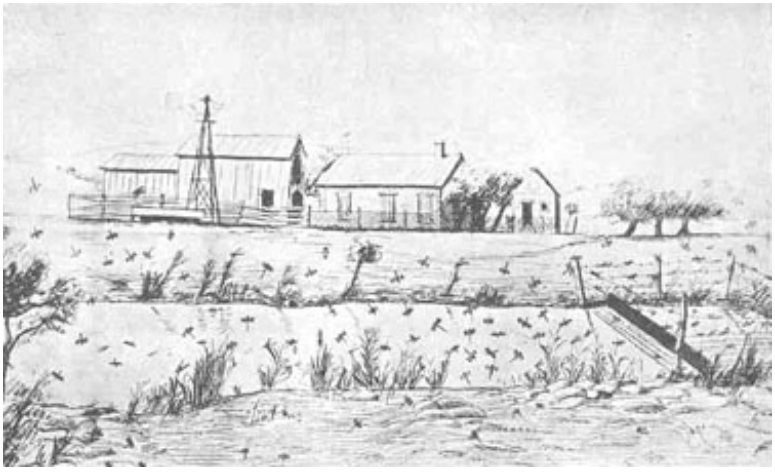
In the photograph marked "Mosquito Breeding Hole" is shown an ideal mosquito-propagating place, as the water it contains is entirely seepage sewer-water. During the years 1908-9-10-11-12-13 and 14, millions of the lordly dragon flies could be seen perched on the telephone wires that parallel the county road. The limbs of the dead trees in the water were literally covered by them, as well as the barbed-wire of thesome eggs, but was more often disappointed than successful in so doing.

As the eggs are more often laid in the middle of the pond, where they cannot be reached from the shore, the author procured a hemispherical basket made of fine wire mesh, something on the order of a canary-bird's artificial nest. To it was attached a hollow tin handle, permitting the insertion of the slender end of a fishing pole. The exact spot where the fly was seen dipping was marked, or better said, not lost sight of, and as soon as possible was scooped with this device, and the contents of the scoop were searched for the eggs. The investigator will make many such scoops without finding an egg, as the fly does not drop one every time she dips her abdomen in water.

After each scoop is made, the resultant contents of the basket must be placed in a vessel containing clear water to facilitate the search for the eggs, which are quite small.

However disappointment will only sharpen determination; and with patience we eventually succeed. On several occasions, the author managed to obtain eggs that hatched, after being taken from abdomens of the living flies. They evidently were fully matured, and soon would have been laid.

In the experimental tub already mentioned, where the eggs of the dragon flies were placed, a fine-meshed bobbinet was fastened several inches above the rim, as the standing water with its abundance of aquatic-plant life made it also an ideal mosquito-breeding ground. The water was thus kept mosquito-free for some time. After several of the dragon flies had hatched and developed into adults, the bobbinet was removed, more dragon fly eggs added, and subsequent developments observed.



Schematic Drawing Illustrating Method of Protecting Dragon Flies.

As was to be expected, it was not long before the surface of the water was swarming with mosquito larvae (wigglers) and adult mosquitoes, without the least interference on thepart of the dragon-fly larvae, which remained on the bottom of the tub, where the mosquito larvae resorted to in order to find food. This was verified by disturbing the surface of the water, which caused the larvae or wigglers, in response to danger, to wiggle themselves to the bottom of the water, where they mingled with the dragon-fly nymphae without being in the least molested by them. It was hardly to be expected that the dragon-fly larvae would attack the wigglers in the water, as the latter creatures constantly require oxygen and spend the greater part of their lives on the surface, while the dragon-fly larvae are constantly submerged until they are ready to develop into the adult fly.

THE CRAYFISH ENEMY

That the crayfishes of the different varieties are great enemies of the dragon-fly larvae in the water is evidenced by

the manner in which that crustacean obtains its food. This cougar of the under-water creatures lies in wait in its hole by the hour for some unsuspecting aquatic contemporary to pass by, when, with remarkable dexterity, its claws are brought into play, and its victim is voraciously devoured. The author has derived a great deal of pleasure from observing these creatures in shallow ponds, where they are found in great numbers, doubtlessly on account of the absence of large fish of prey.

AUTHOR'S EXPERIMENTATION

If the larvae of the dragon fly in Nature have other enemies in the water, the author has never been able to find one, though he does not assume to be so presumptuous as to claim there are none, or to make any positive statement to that effect. Positive results can be obtained only by long, hard work and unlimited patience, involving a great deal of time. Hard work, in delving into the habits of any of Nature's creatures, has never been anything but a pleasure to the author; and, if patience had to be associated with or become a necessity in that endeavor, it was never wanting. It is certain, however, that there were no enemies in the tub; and the intention in placing mud from the bottom of the pool in the experimental vessel, was with a view of making their presence feasible or even convenient. It is quite possible that the imitated natural conditions were of a degree of perfection sufficient at least to have revealed some enemy, had it been there.

The aquatic plant commonly known as water-wort seemed to be the favorite rendezvous for both the larvae of the dragon fly and the larvae of the mosquito, on account of its delicate leaves being provided with vacuum cups forming receptacles that retain the organic matter in the water, which matter furnishes food for innumerable forms of low animal aquatic life.

It must be mentioned that the author's residence where these observations were made is within a stone's throw of the geographic centre of the City of San Antonio, and that the mosquitoes in all of these experiments were invariably of the diurnal variety. In not a single instance were the malarial-mosquito eggs or their larvae or puppae, found in the tub, confirming the knowledge that the malarial mosquito is distinctly a rural insect. Since natural conditions had been provided for them, the dragon flies developed in the tub, just as they would have developed in Nature, and so did the mosquitoes—but what was the result of the experiment?

The dragon flies captured and ate hundreds of the mosquitoes almost as fast as they developed; but here again we see a wonderful provision carried out by Old Dame Nature in the Conservation of her different species of life, in that while a batch of mosquito eggs hatch out into wigglers practically simultaneously, they do not ALL become adults at

one time. Nature knows better than to place all of her eggs in one basket, so she causes only a few at a time to become adults, knowing full well the numerous vicissitudes and the many enemies they must encounter. But the few remaining dragon flies in the vicinity of the tub held the great army of mosquitoes in check, for the author and his neighbors were not particularly bothered by them.

To continue the experiment, the tub was emptied, and the conditions were reversed, that is the tub was not refilled with water until the dragon flies had all left—even after occasional visitors had concluded that places other than the author's back yard were better for them, so ceased their visits entirely. Two weeks after refilling the tub, the author in self-defense, and out of consideration for his neighbors, was compelled to empty it, the experiment having concluded itself. The mosquitoes, not being in the least molested by one of their most formidable enemies, simply swarmed about the neighborhood. There was no room for doubt as to the cause of the difference in the two experiments, but the practical application with its merits, and with the exclusion of its demerits, is the big problem that will confront the investigator. How can dragon flies be cultivated in any receptacle without breeding swarms of mosquitoes?

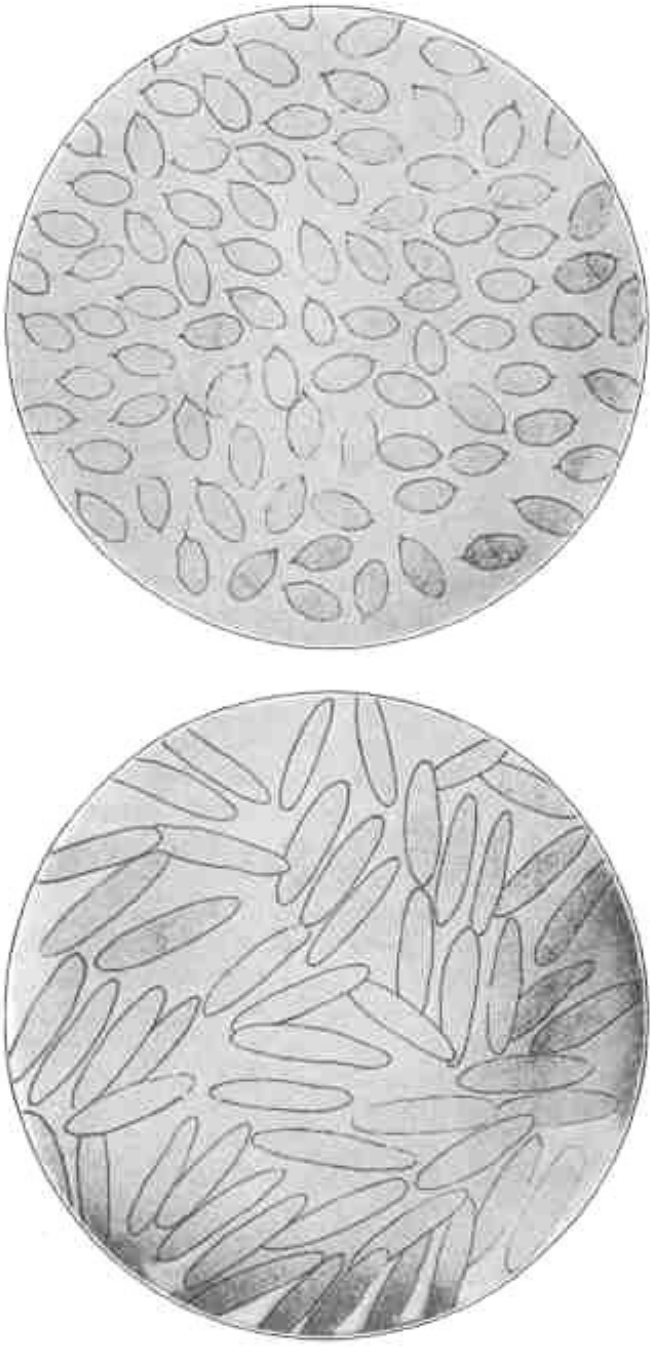
ANCIENT INFORMATION CONCERNING THE DRAGON FLY'S VALUE

It is, indeed, strange how we sometimes find information, empirically gained, hidden in some remote part of the world, which, when brought to civilization, is of untold importance to humanity. As an example of such information, long recognized but long delayed in leaving its source of origin, may be mentioned the knowledge of the value of these beautiful creatures, the dragon flies, realized for centuries by the lowly peasants or peons in some of the innermost recesses of the State of Cordova in Mexico.

The narrative that follows had its origin in the coffee-growing districts of that State, where yellow fever is practically endemic. The natives, mostly of Indian origin, knew that mosquitoes convey yellow fever, and that dragon flies prey on mosquitoes and would annihilate the said fever, if they but come in sufficient quantities. This was ascertained by simple deduction and practical observation, and was handed down to them by their ancestors. An old and highly respected citizen of San Antonio states that, in his young manhood, he was engaged in the business of coffee-buying in Mexico, that his itinerary embraced the innermost parts of that State, and that he travelled in all manners and fashions.

One day, on arriving about noon at a small hamlet, he put up his team, and after a short lunch and the conventional cup of coffee, like the natives, he resorted to a siesta. There was no difficulty in obtaining perfect quiet to insure the accustomed nap, as during these hours silence reigns supreme,

when everybody is enjoying his siesta. These are no hours for business. He had hardly slept more than a quarter of an hour, when he was awakened by a perfect bedlam of all kinds of noises; shouts, yells, cries, vivas, blowing of horns, ringing of bells, beating of drums and cymbals, hoes detached from their handles and suspended with a string, pinch bars balanced and made to serve as triangles; in fact, everything with which a noise could be made was resorted to by the natives, who formed a procession marching in great glee up and down the only street in the hamlet. On coming out of his room to ascertain the cause of the row, he heard the cries of *"Ya vino el mosco, ya vino el mosco! Se acaba la fiebrel se acaba la fiebre";* which translated, means "the fly has come; the fly has come! The fever will stop, the fever will stop!"



Dragon Fly Eggs (highly magnified).

"With the greatest interest he watched the happy dancing natives in their child-like exhibitions of glee, and understanding the Spanish language, he wondered what connection the word "mosco," which means a large fly, could have in converting a sleepy old hamlet into a bedlam of noises, associated with so much joy. But as all the noisy merry-makers had uplifted faces, one glance at the skies, told him that the "moscos" were dragon flies which had descended on the hamlet in huge swarms, literally filling the air. A short walk brought him to the place of the general storekeeper (from whom he bought coffee), who, with some of the plantation owners, was contentedly watching one of Nature's marvelous displays that represented great commercial value to them. These men of the higher and educated classes, explained to our coffee-buyer, that, when the dragon flies came in such numbers, the yellow fever, which interfered so much with the labor employed in their enterprises, would be entirely routed, as the flies came to prey on the mosquitoes that convey the fever, and in a short time, would completely exterminate them. They further told him that all of the natives knew the value of dragon flies, and early taught their children never to kill a single one, the information having been handed down for centuries from generation to generation.

This huge migration on the part of these valuable creatures occurred in the fall of each year. Thus we see that information of incalculable value was indeed ancient knowledge centuries before our noble American scientists made their wonderful discovery in Cuba.

MICROSCOPIC INVESTIGATION

As the food of dragon flies is principally mosquitoes and other small insects, the student will find great interest and good entertainment in the study of the scatology of these creatures, the necessary accoutrement being a lower-power microscope, such as can be bought from any optical-goods dealer, a few concave watch glasses, and a vial of peroxide of hydrogen. To obtain the best results, the large dragon flies ought to be captured as late of an evening as possible. They are then placed under a convenient glass globe over the bottom of which is spread white paper. The next morning on the paper will be found several small pieces or pellets of excrement. These are then placed on the watch glass, and a few drops of the peroxide are poured on them. An effervescence will be observed; and after that subsides, the little masses will have fallen apart, the peroxide having dissolved the mucous that binds the individual pieces together.

If we then place the watch glass under the microscope, we shall find the skeletal remains of the insects the fly has devoured; because, as already mentioned in the study of the scatology of bats, the external body of all insects is of that

character of tissue known as chitin, which is perfectly insoluble, and hence passes through the digestive system of the dragon fly intact, except that it is found comminuted by the chewing or grinding apparatus of the insect. Further amusement and entertainment can be had, if we will catch a number of mosquitoes, and, after they are perfectly dried, in imitation of the grinding apparatus of the dragon fly we will chop them up very fine with an old safety razor, we shall obtain the identical conditions of the pellets or excrement. When we place them in a watch glass and add a few drops of peroxide of hydrogen, we shall get the same picture.

The peroxide dissolves out the albuminous matter, leaving the chitin untouched, on account of its insolubility. In this manner we become familiar with the comminuted chitinous remains of mosquitoes from the bodies of dragon flies. More interest can be added to the study, if we make hand-drawings of the individual pieces we see under the microscope ; and we shall become so familiar with the comminuted pieces of mosquitoes, that we shall immediately recognize and distinguish them from the comminuted remains of other insects in the pellets we examine.

THE TOP-WATER MINNOW

The top-water minnow, which has received many well-deserved encomiums as a destroyer of mosquitoes, is also a great enemy of the dragon fly. The success in combating mosquitoes with this little fish and its different species in large bodies of water depends on the presence or absence of larger fish. With this feature of such warfare the author has had considerable experience, for he possesses a large reservoir of flowing water where he raises fish for study, pleasure, and food. As the whole of life is a question of food, conditions for food for the food-fish were well considered.

AUTHOR'S FISH CULTURE

When this body of water was adopted for fish culture, there were profusely provided aquatic mosses and plants. When these had attained sufficient growth, top-water minnows by the thousands were placed in the water, not for their mosquito-destroying value, but for their value as food for other fish. The planting of the aquatic plants in the edge of the water was for the special protection of the minnows. By continuous feeding of ground meat and table scraps, they multiplied in great numbers.

To the reservoir were then added the different species of perch by the hundreds, and lastly, the different species of trout or bass intended for culture, and found in this vicinity. The venture is a success, as the bass feed on the perch, and the perch in turn feed on the minnows that are practically hand-fed. These little fishes increase rapidly because of the fact that they do not spawn like their higher or larger brothers,

so have no eggs to pass through the different vicissitudes, or to fill the yawning maws of aquatic enemies—they bring forth their young alive. Notwithstanding this feature, plus the splendid protection the aquatic plants afford them, and the abundance of food they receive, the author is compelled every now and then to replenish his stock of minnows to feed the perch, which in turn feed the bass.

SUGGESTED BREEDING GROUND FOR DRAGON FLIES

As most farms are compelled to have earthern tanks to impound water for their stock, and as such places are excellent breeding grounds for mosquitoes, and as none of the usual mosquito-destroying methods can be applied to them, the author offers a plan, which the schematic drawing illustrates. One end of the tank is fenced with barbed wire, and on the inside of the enclosure, ordinary wire is stretched from bank to bank, and reaching to the bottom of the water. The barbed-wire fence is to keep out stock, and the wire netting to keep out the enemies of the dragon flies and their eggs, which are top-water minnows, crayfish, and the different species of perch, which are the enemies of the species of dragon flies that go under the water to lay their eggs.

This scheme also conserves the different species of the smaller dragon flies, the agrionidae—the species shown in the cut as having the slender abdomens. These species seldom wander any distance from the water, and usually rest on floating weed or water-moss, dipping their long and delicate abdomens in the water while in the act of ovipositing. It is then that the small perch nips off the slender abdomen, which, of course, kills the insect. As the suggested fencing is inexpensive, it is hoped many such places will be made for the conservation of one of Nature's creatures whom we know to be an enemy of the arch fiend of the insect world.

EXPERIMENTS ON OILING OF WATER

Under the dense shade of a large pecan tree, in the author's back yard, a wooden tub was filled with cistern water for the purpose of breeding mosquitoes, and of observing the effects of the oiling method in their destruction. Almost the next day eggs were found on the surface of the water, which duly hatched out into the larvae or wigglers. When these were about half grown, the surface of the water was given a liberal coat of kerosene oil, as that oil spreads much better than does any other. Of course, all of the wigglers in the tub, including the new arrivals were drowned, but on the morning of the 7th or 8th day after the oiling, the surface of the water was again well dotted with mosquito eggs laid in between the islands of the gummy residuum left by the evaporating oil. When these hatched out, the wigglers, coming to the surface of the water for air, on encountering a lump of the residuum, would wiggle about until they found an open breathing space between the

islands.

There is nothing original or singular about this procedure, except that, in the course of time, the water, on account of the many layers of oil being churned into it by the frequent additions of fresh water poured into the tub to make up for evaporation, became so impregnated with the oil, that none of the ordinary minute aquatic plants that usually find their way into bodies of standing water developed in the tub. The domestic animals about the yard refused it as drinking water, yet, notwithstanding all this, the mosquitoes continued to lay their eggs on the water in the tub as though it were perfectly fresh, and these eggs hatched out into larvae and pupae, until they were killed off by a new layer of oil.

In the outskirts of the City of San Antonio a pool of standing water was formed in the bed of a dry creek, some three hundred yards below a large artificial lake. The pool was about 18 feet long, six or eight feet wide, and from nothing to fifteen inches in depth. This depth was fairly constant, as it was formed by seepage from the big lake, though during very dry times the level of the water in there would fall so low as to cause the pool to go dry.

It was to this pool that the author so often resorted in the study of dragon flies, on account of the natural conditions there prevailing. The total absence of the top-water minnow, on account of the pool at times becoming dry, the slimy ooze, the aquatic moss and other numerous kinds of water plants, the huge complement of miscroscopic aquatic fauna, and, to make conditions more ideal, the dense overhanging brush on one of its banks afforded the requisite shade. This was the place selected for the study and observation which so forcibly reveal the fallacy in the oiling method mentioned in the concluding paragraphs of ALLEGATION THREE, and which will impress with its demerits the sanitarian employing this method of mosquito eradication.

The author spent hours and hours at this natural mosquito-and-dragon-fly breeding place, observing the latter creatures in their antics, dartings, quarrels, love-making, and continually dipping of their abdomens in the water in the act of ovipositing, and, in particular, the beautiful different iridescent colors of these miniature natural aeroplanes. Nothing that moved in their world seemed to escape their large limpid eyes.

This pool seemed to be quite a resort for these creatures, as frequent visitors made their appearance, darting here and there, but remaining for a short time only. There seemed also to be among them some toughs and bullies, as the permanent residents yielded their favorite places for observation to the visitors, without the least protest, resuming their points of vantage only after the usurpers had left.

Dragon flies could be seen in numbers disporting over the surface and on the shore of the large lake, and also perched on

convenient places over a small pool immediately below the dam. This small pool was teeming with top-water minnows.

A little before sunset it seemed as though all of the dragon flies from the lake and elsewhere came to our pool; the air was full of them. This is readily accounted for, because the mosquitoes that bred in this pool in countless numbers were principally of the nocturnal varieties, as there were hardly any seen during the day. Those that hatched out during the day were devoured by the dragon flies, and those that escaped, of course knowing of the immediate presence of their enemies, hid away until evening in the dense brush that afforded the pool the requisite shade.

When the student attempts to capture one of these creatures with an ordinary insect net, he will become acquainted with their remarkable vision and their rapidity of flight, as he will make many dashes with his net, only to find the dragon fly just a little ahead of it. He will soon learn that, to capture one, it will be necessary for him to swing his net as hard as he would swing a baseball bat to swat a ball when all the bases are full.

As the pool was some three miles from the author's home, and as most of these observations were made before the universal use of that wonderful invention, the automobile, that distance had to be covered with a horse and buggy and was of some moment, as it meant considerable loss of time to travel six miles there and back to the "mill," the author's private office, from where he, the "miller", obtained the necessary means for the sustenance of his little family and for the prosecution of his experiments. Therefore he again resorted to his old wooden tub, and converted it into use for a check, or parallel observation, on the mosquitoes in the pool, since the behaviour of those in the tub would be the same as that of those in the pool three miles away.

Accordingly, he refilled the wooden tub in his back yard with rain water, and, to imitate conditions in the pool, added a lot of mud and decaying leaves. The next day many mosquito eggs dotted the surface of the water; and, when these hatched out, the water in the pool was covered with kerosene oil, as was the water in the tub. Of course, the mosquitos in both the tub and the pool were killed.

After a wait of eight days, the water in the tub was again well dotted with mosquito eggs, and an observation of the water in the pool showed the same. After the lapse of a few days more, both tub and pool were again oiled, and again the mosquito larvae were killed. Convinced that the parallel tub had well served its purpose, it was emptied and turned upside down. After a lapse of ten or twelve days from the second oiling, the pool was again oiled, but this time with most painstaking care to cover the smallest surface of the water; in fact, oil was used in profusion, as this was the last oiling it was to receive.

In the immediate vicinity of this pool were several very poor Mexican squatters who had erected their humble little huts out of scrap tin and scrap lumber, binding the side walls with mud, and living practically under the brush arbors erected in front of the dwellings.

With the very first oiling the dragon flies left; hardly a single specimen was to be seen, where previously countless hundreds or even thousands found a happy home. Three weeks after the oiling was stopped, mosquitoes swarmed there in such numbers that the poor Mexican squatters, who had so laboriously built their huts, were compelled to tear them down and move away. The Mexicans of this class are the most humble and uncomplaining people imaginable; and when the mosquitoes got too bad for them, they must have been indeed intolerable. They related to the author, that, before the oiling, they were not in the least molested by mosquitoes during the day, but after the last oiling, they could not even enjoy their siesta in the afternoon; and at night their huts became a swarming mass of mosquitoes whose onslaughts were simply unendurable, hence they were compelled to move from that locality.

From this we see that, while the first and the second oilings most effectively destroyed the mosquitoes developing in the pool, it also most effectively destroyed the larvae of the dragon flies which were constantly developing in the same water, as, in emerging into adult life, they were compelled to pass through the layer of oil to reach the surface and out of the water entirely to emerge from their chitinous shell. In fact, the second and the third oilings were spaced with the view of destroying the larvae of the dragon flies, as in quite a number of instances these take some time to develop.

As already stated, a very short time after the first oiling the dragon flies left this pool, and so complete was this migration that the next day, after hours of patient observation, hardly a single fly was seen; and towards evening, when they used to come by the thousands, not a single one put in its appearance. They had migrated to some other pool or pond, where the natural conditions had not been disturbed, and where they could continue to live their lives as their Creator intended they should. But to the mosquitoes, with their prolificacy, this disturbance of Nature was only temporary and greatly to their advantage, as it rid them of an active enemy, leaving them the pool all to themselves.

The experiment thus carried out clearly proves the fallacy in the oiling method of mosquito eradication, and demonstrates how Nature resents any interference in her wonderful balancing. It also indicates the constancy and fidelity which must attend the method to overcome its fallacy, for otherwise, it will result in defeating the very object we desire to attain, viz, the eradication of mosquitoes.

SUGGESTED CONTINUATION OF EXPERIMENTS

As there is so much to be learned about these valued friends of man in the insect world, the author will continue their study at every opportunity that presents itself, as it involves the learning of the habits of a diurnal enemy of the mosquito, which enemy we are indeed fortunate in possessing. It was suggested in the beginning of this writing that some young and enthusiastic student take up these studies; and, if such a person enter this field and think the author can be of the slightest assistance to him or her, that person can rest assured that whatever information the author has will be cheerfully given. If the problem pointed out, viz, the cultivation of dragon flies in a receptacle at hand wherever wanted, with the exclusion of breeding mosquitoes, can be solved, it will not only bring name and fame to crown his or her efforts; but deep down in the innermost recesses of the heart will firmly be imbedded the proud satisfaction of doing the noblest of all things, helping one's fellow man.

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PART III

Résumé of Experiments on Variola

By CHARLES A. R. CAMPBELL, M. D.

San Antonio, Texas

My Observations on Bedbugs

By CHARLES A. R. CAMPBELL, M. D.

San Antonio, Texas

Eradication of Small Pox by Other Means Than Vaccination. (Founded on the above.)

By J. A. WATTS, M. D.

San Antonio, Texas

Dedicated to the People of Mexico

Foreword

By

J. A. L. WADDELL, D. E., LL. D.

In the summer of 1905, whilst passing through San Antonio, Texas, the writer was suffering from a simple ailment that needed medical relief; consequently he enquired as to the name and location of the leading physician of the city, and was directed to Dr. Campbell. After the medical attention was given, the Doctor and the writer drifted into a friendly discourse and discovered in the course of conversation that they possessed many tastes in common, but especially a love for scientific investigation and research. At this meeting there was formed between them a firm friendship that has endured ever since.

Meeting for a while once every few years and of late once or twice a year, and by a somewhat irregular correspondence, the writer has been able to follow closely the Doctor's important investigations; and it is really due to his suggestion

and oft-reiterated requests that the preparation of this book was undertaken and brought to a conclusion. The writer has long felt that the results of all of his friend's wonderful and intensely interesting nature-studies should be brought to the attention of not only the medical profession throughout the world but also of all those intelligent, thinking people who are interested in the works of nature and in the methods of utilizing them for the benefit of mankind. For this reason the writer advised that the subjects of the book, while being treated from a truly scientific standpoint, should be handled in a semi-popular style, in order to catch and hold the interest of the intelligent layman; and a perusal of the manuscript has shown the writer that his advice has been closely followed in a most successful manner.

At their first meeting the Doctor told the writer in close detail about his experiments on bedbugs and smallpox, and then-and-there converted him to a belief in the theory of their connection. The writer, recalling some of his personal experiences, stated that French Canadians are much afflicted with smallpox and that most of their houses are over-run with bedbugs—also that the Canadian Indians are great sufferers from that dread disease, which has often been picked up by going into their abandoned tepees or huts. This is so well known in the Canadian wilds that such old habitations are avoided with dread and passed with a shudder. Old discarded clothing has long been recognized as a carrier of contagion, although nobody in Canada had ever dreamed of the transmission of the disease being due to insects, in spite of the fact that such abandoned huts and clothing were known to contain bedbugs. The writer has seen lumbering shanties, both occupied and deserted, swarming with bedbugs and fleas —in truth, it was never safe in Canada to enter them, if one dreaded the contact of such filthy and pestiferous insects.

Dr. Campbell told the writer of his ardent desire to go to Mexico, in order to experiment upon jail-birds, who would be only too happy to lend themselves to the cause of science, provided they were given their liberty after the investigations were finished. It seems that there is no law in Mexico to prevent the making of experiments that would jeopardize the lives or healths of human beings, but that in our country there is such a law—and a stringent one.

All that Dr. Campbell then needed for his proposed investigation was the pitifully small sum of twelve thousand dollars. The writer gladly promised his aid in securing that amount from some rich American philanthropist or from some established fund for research; and during several years he did his level best to keep that promise, but all his endeavors were unsuccessful. The fund moneys appeared to be so tied up with red tape that they could not be utilized for outside purposes; and the millionaires did not care to spend their dearly loved dollars for any such philanthropic purpose. The writer must have made at least a dozen distinctly different attempts to raise this money. Once he had great hope of success, because the individual approached was a Texan who had inherited

considerable wealth and had much more money than he knew how to spend. In spite of all the writer's eloquence and his demonstration of the undying fame that would accrue to the donor of such a fund, he was curtly told "nothing doing," thus proving the said Texan to be as effective a "tight-wad" as had notorously been his sainted parent.

However, the Doctor was not in the least disheartened—quite the contrary. This failure to procure for him financial aid only sharpened his dogged pertinacity; and, notwithstanding the burden and care of a family to be met by the lucrative (?) occupation of practising medicine for a living, he has never swerved from the goal he had set for himself, viz., aiding humanity by the results of his numerous and varied experiments on insect-borne diseases and how to combat them. This is proved by the success of his monumental work in relation to the prevention of malaria by the extermination of the malaria-bearing mosquito through the propagation of its natural enemy, the bat. This work he accomplished unaided, single-handed, and under most trying conditions; and, in no uncertain terms, it testifies to his great value and places him in the front rank with the world's leading scientists.

The writer has not yet given up all hope of seeing these bedbug experiments carried out in Mexico, because the conditions there today are just as favorable for the purpose as they ever were. It may be that the publication in book form of the wonderful results of Dr. Campbell's life-work will induce some rich man or woman to offer the necessary money for the prosecution of the good cause.

Such a person, though, would have to be of a different temperament and caliber from those of one of the directors of the Rockefeller Institute, who, when approached by Dr. Campbell himself with a request for this money, held up his hands in holy horror and exclaimed "What! Furnish you with money to experiment upon human beings! What do you think the American people would say, were I to do such a thing as that?"

Some seven years after his first meeting with Dr. Campbell, the writer read in a scientific paper that a Russian scientist, whose name has escaped his memory, had, independently without doubt, made the same discovery as did Dr. Campbell in relation to the connection between bedbugs and smallpox. Curiously enough, although the fact of such a relation has been mentioned several times in the press, very few members of the medical profession appear to have heard anything about it. This has repeatedly been made evident to the writer during conversations with medical men.

In the writer's opinion, Dr. Campbell has proved beyond the peradventure of a doubt that smallpox is transmitted in one way only—by the bite of an infected bedbug, or possibly in rare cases by that of another blood-sucking insect, the *"chinche volante."* Such being the case, is it any longer necessary to continue that most objectionable practice,

vaccination? While the great mass of humanity may have been benefited by that practice, many individuals have suffered greatly and even died from the poisons vaccine sometimes introduces into the blood. The writer has long felt that he would far rather risk catching the smallpox than undermining his health by taking into his system a poison that might have much worse effects than those of *la petite vérole.*

Résumé of Experiments on Variola

By CHARLES A. R. CAMPBELL, M. D.

San Antonio, Texas

Mr. President and Members of the
Bexar County Medical Society:

There must be some motive for a member of the same professional household to keep in the background such a work as I am about to present for your consideration this evening. This motive is that I hoped some avenue might present itself permitting me to continue the work to the point of carrying out further experiments to such a degree of scientific certainty as would place it beyond the possibility of contradiction. It was my ambition to go into Mexico, where, with knowledge of the language and customs of the people, I could have obtained the cooperation of the "powers that be," and of the medical profession, and could there have completed the investigation. There never was a doubt in mind that I could have had this cooperation, as it was freely offered to me from that country, but the lack of finance was the insuperable barrier.

As it is now my intention to publish this work, though I do not know when or where, I desire out of respect to my home professional brothers and home society to present it to you first.

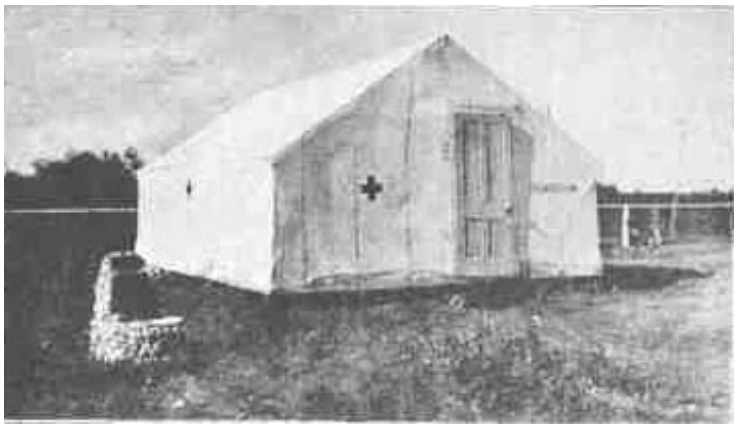
The work of the Eradication of Malaria by the Cultivation of Bats, The Mosquitoes' Natural Enemy and Destroyer, on which I have been engaged, as you are all aware, for the past twenty years, is more important and far-reaching in its benefits to mankind than this work, and I purpose for the rest of my days to concentrate all of my energies, spare time, and money on the continued studies of that most benevolent, though misunderstood creature, the common bat.

I desire to return thanks before this Society to my good friend, Dr. W. L. Barker, who, appreciating my endeavors, had me placed in charge of the Pest House, where I found opportunities of pursuing this research on smallpox, which I could not have had without his kindly intervention. I also owe my thanks to Mr. Thomas Patino, my head nurse, who is a highly valued employee and most kind and sympathetic to the

unfortunates under his care.

The papers in the order of their presentation are, "Résumé of Experiments on Variola," "My Observations of Bed Bugs," and Dr. John Watts' valuable work and observations on this disease, which he presents under the caption of "Eradication of Smallpox without Vaccination or Disinfection." The author made Dr. Watts thoroughly acquainted with the result of his smallpox-bedbug investigation, on account of the Doctor's going to locate in Mexico, where the disease is so common, and requested him to continue the work in that country, on the lines indicated in the above mentioned papers. How well he carried on the investigation his paper will tell.

Some years ago, while travelling in Mexico, I learned that the Mexican mothers of the lower classes find a great deal of consolation when their children have had the smallpox. They regard it as inevitable; and, in order to get through with this trouble as soon as possible, they place the well children upon the same bed as the one having the smallpox, so that they may become infected with the disease.



"Disinfection" tent at San Antonio Pest House. The only disinfection done was to look for bedbugs in the clothing of the patients or those to be held in detention.

The de luxe quarters of the pest house; author's horse and buggy.

Row of tents for persons held in detention on account of having been exposed to smallpox. Separate tents for whites and negroes.

I was also told by these lowly people that those who sleep on the outside of the houses, upon nothing more, perhaps, than a sheep's skin or raw hide cot or bed, usually escape the disease—hence the mother places the children who are well upon the same bed with the sick ones. This information was kept in mind by me until I had occasion to see a few cases in the City of San Antonio, Texas. In considering this malady, I quickly became impressed with two distinctive peculiarities of it, viz: Its being a disease of the winter and of the coldest climates, and that, as a rule, it is confined to the lower or filthy classes.

Having followed very closely the current literature concerning the brilliant work done by Drs. Reed, Carroll, and Agramonte in yellow fever, the above peculiarities caused me hypothetically to ascribe to the bedbug the quality of being the diffusing agent of variola. (As to the bedbug's power of resistance to intense cold, water, and starvation, see my "Observation on Bedbugs.")

Assuming that bedbugs are the only diffusing agents of this loathsome disease, then our present knowledge of its being "air-borne," or of its being transmitted by fomites, must be all wrong, therefore the principal work here mentioned is the demonstration of its non-contagiousness by means of clothing, bedding, hangings—in short, fomites.

I then began to experiment with this disease directly by contact and to expose some person to it who had not had it. I selected as this person one whose movements I could at all times control and understand, and, therefore, I chose myself. As even the air itself, without contact, is considered sufficient to convey this disease, and touching the clothes of a smallpox

patient considered equivalent to contracting it, I exposed myself with the same impunity as my pest-house keeper, who is immune, having had the smallpox. After numerous exposures, made in the ordinary manner, by going from house to house where the disease was and demanding, under legal authority, the removal of the patients, as well as members of the family, to the pest house, I have never conveyed this disease to my family, or to any of my patients or friends, although I did not disinfect myself or my clothes nor take any precautions whatever, except to be sure that no bedbugs got about my clothing.

Another one of my experiments was thoroughly to beat a rug in a room, only eight or ten feet square, from which had just been removed a smallpox patient. This rug had been given to the negro family in question by a white person after his family had utilized it until it was useless for them, and thereafter it had been used for years by the said negro family. I beat this rug in the room until the air was stifling, and remained therein for thirty minutes. This represented the respiratory as well as the digestive systems as accepted avenues of infection. While *I* was exposing my person to this experiment of inhaling particles of organic, as well as micro-organic, matter, I never lost sight of the fact that I was engaged in trifling with the system of knowledge which had been handed down from generation to generation, each one accepting as true what the preceding one had written. I also remembered that, if such men as composed the scientific expedition to Cuba for the investigation of yellow fever had adhered to the old-time and accepted theories that bedding, carpets, clothing, hangings—in short fomites—were the conveyors of yellow fever, we would not now have the knowledge which these gentlemen so nobly acquired and generously gave to the public in the interest of mankind, consequently I continued my experiments. After inhaling the dust from that rug, I examined my sputum microscopically the following morning and found cotton and woolen fibres, pollen, and comminuted manure, as also bacteria of many kinds.

Convinced that I had given my respiratory and digestive systems ample opportunities to afford avenues of infection, from that time on I mingled freely with my family, patients, and friends; but, for the first fourteen days after the experiment of beating the rug and inhaling the dust, I slept in my office for fear of conveying the disease to my family.

Ambulance House, Feed Room, and Stable, connected with the San Antnio Pest House

The next experiment was the exposure of two city carpenters, two laborers, and myself. Three of these men had never been vaccinated, and the fourth only in infancy. This experiment consisted in tearing down an old privy at the detention camp or pest house, which privy had been used four or five years by smallpox patients only. It was constructed of 1 x 12 inch slats and boards. With hatchets and levers the old structure was soon razed; and the foul-smelling lumber was carried by each of us a distance of one hundred yards and neatly re-constructed.

As the day was very hot and our water supply some distance from the work, I placed a bucket of water about ten feet from the work and in such a direction with the wind that the dust from the sawing and nailing of the old boards would fall into the water. Of course, the laborers did not observe my object in so doing, and they and myself all drank freely of the water till noon. After dinner all of us worked on that foul-smelling structure and drank of that same water till evening, when the work was completed. None of us ever felt any bad effects from our exposure. I had these men under my observation for fourteen days after this experiment.

In five instances where the disease made its appearance in the homes of negro washerwomen, I found two and three weeks' washing laundered and ready to be delivered to the owners. It is a matter of common knowledge that negro washerwomen, when ironing clothes, place them upon beds to keep them from becoming wrinkled, and these articles of clothing, when discovered in an infected house, are generally burned by the health authorities, the owners being reimbursed from public funds; but in each of the above instances I took the clothes to the pest-house grounds, and, spreading them upon the grass, I carefully searched each piece of clothing for bugs. Not being able to find any bedbugs on any piece, I returned all the clothing to the owners without any disinfection whatever. These clothes did not convey the disease to anyone.

Anita H., a Mexican child, four years of age, never vaccinated and who had never had the disease, was taken to

the pest house, where she took a baby out of the crib and played with it about four hours, hugging and kissing it and riding it in a perambulator around the grounds; but, although this baby was covered with pustules of smallpox, and although we took no precautions whatever (the girl's mother having agreed to this experiment), the girl did not acquire the disease.

J. C., brought to the pest house in a vesicular stage, made an uneventful recovery after passing through the typical states. In this case I caused the bed clothes of his bed to be undisturbed when he recovered. This same bed, without any change in the bed clothes, was then occupied by L. M. This individual had never been vaccinated nor had smallpox, and understood that he occupied this bed as an experiment. He did not acquire the disease.

P. H., a Mexican, vaccinated in infancy, who freely mingled with the smallpox patients in the discharge of his duties as night watchman at the pest house, keeping up the fires and remaining all night, did not contract the disease.

A. C., decidedly strumous, never vaccinated nor had the smallpox, freely mingled with smallpox patients in all of the stages, playing cards with them, eating and sleeping in the infected tents, and has continued to do so for more than two years.

Mrs. T. P., wife of the Pest-House keeper, aged 26, vaccinated in infancy, acts as nurse and cook and freely mingles with the female patients.

Master E. P., and sister, aged respectively eleven and nine, the former vaccinated nine years ago, the latter unsuccessfully, play with children in all of the stages of smallpox and play with the toys of the little patients, without the least harm.

Personally, I have not only come into direct contact with smallpox patients many times, but have taken off and rubbed my outer clothes on the beds of the patients and then returned to the city and mingled freely with my family, friends, and patients, without disinfecting at all.

In one instance, which I believe is worthy of special mention, a man, his wife, and four children were here, and three of these children became infected with the smallpox. I took all of them to the Pest House, and as all of them preferred to stay in one room, I placed them together. The man and his wife had previously had the disease, and only one child escaped it. I kept them at the Pest House until the eighteenth day after the period of desquamation on the part of the case developing last. They were returned home upon a Saturday morning. Observe that this child, although living in the same room with the patients at the Pest House, had not acquired the smallpox, after being exposed to it all of the time for a period of six weeks; yet upon the fifth day after returning home, this child acquired the initial fever. *I* then examined their house

and found it to be literally alive with bedbugs.

In addition to these experiments, it should be remembered that I had at the Pest House half a dozen employes, who washed, scrubbed tents, etc., and these persons were employed by me especially because they were non-immune—and yet none of them ever contracted the disease.

Among some of the cases coming under my observation and care, which did not originate here, is the following: The patient, a girl of eleven years, had a fairly-developed case, and was at one of our hotels. I took this patient and her father and mother to the Pest House, in the meantime locking the door of the room at the hotel and leaving orders that no one be allowed to enter it until my return. This room had been occupied two days and nights by the patient. Upon my return I carefully inspected the bed and the en-

tire room, particularly the walls and ceiling, and not finding any bedbugs, I told the hotel proprietor that the room was again all right; and it was from that time on occupied. All of the occupants were kept under careful observation, but not a case developed in any of the persons occupying the room.

Another case was that of a little girl who was seized by the disease in Mexico about eight hours before reaching San Antonio. This little patient's family consisted of her father, mother, and little brother, eight years old. I took them all (under protest) to the Pest House. The man I allowed to leave and go to the city and return, as he pleased; and, with my consent, he procured a horse and buggy from a livery stable and took his wife riding every day. At night they went to the theatre, returning to the Pest House to sleep. He also bought a doll for the little girl; and she played with it, being at the time thoroughly covered with smallpox. She made a dress for this doll, slept with it at night, kissed it, and played with it continually, until about the fourth day, when she became displeased with it; and after some consultation, her father returned it to the store where it was purchased, and exchanged it for a larger doll. The clerk from whom the purchase was made was kept under secret observation for a long time, but nothing developed from the exchange.

A woman, returning from Mexico, stopped over in Eagle Pass to rest, as the "small of her back was nearly breaking in two;" she placed a plaster on her back to obtain relief, resuming her journey the next day. A day or two after her arrival in San Antonio she developed smallpox and was taken to the Pest House. The day being cold and the Pest House some distance from her room, she sent out and bought a fine blanket to cover herself on the road, using it as a shawl. On arriving at the Pest House, the room being nicely heated, she took the blanket off, placed it on a chair, and got into bed. One of the attendants overheard the keeper's wife ask her husband to bring her from the city a new blanket for their new baby, three weeks old. When he left the Pest House to get this patient, thinking the new blanket was the one intended for the

new baby, he folded it up and brought it to the keeper's wife, who proceeded to wrap up her baby snugly in it. The mistake was not discovered for one week—yet the baby did not acquire the disease.

In the case of the woman, it is curious to note that the area of skin covered by the plaster already referred to, which had been left on the patient's back, was not attacked by the disease, the underlying skin remaining perfectly normal, although there was not a half inch square on her body that was not marked by the disease.

After making a great many of those experiments at the Pest House—(it may be well to say that I had previously destroyed all the bedbugs)—I procured a large flag-pole, with a large yellow flag, and made the occasion of the planting of the pole and the flag-raising a little feast-afternoon, with a banquet, to which were invited the City Council and the officers of the City Government. Liquid and solid refreshments were served, speech-making was indulged in, laudatory of the experiments, by some of the aldermen and other officials present, who knew well of the work I was doing. Evidently they must have had some faith in it, when they so gladly came to a Pest House (and almost in direct contact with smallpox patients) to attend a banquet and honor me by their presence. Some eighteen or twenty attended and remained two or three hours; one alderman in particular, who had never been vaccinated or had the disease, came in direct contact with a patient whose body was covered with the characteristic eruptions.

The most important observation on the medical aspect of this disease is the cachexia with which it is invariably associated and which is actually the soil requisite for its different degrees of virulence. I refer to the scorbutic cachexia. Among the lower classes of people this particular acquired constitutional perversion of nutrition is most prevalent, primarily on account of their poverty, but also because of the fact that they care little or nothing for fruits or vegetables. That a most intimate connection exists between variola and scorbutus is evidenced by the fact that it is most prevalent among the poor or filthy class of people ; that it is more prevalent in winter, when the antiscorbutics are scarce and high priced; and, finally, that the removal of this perversion of nutrition will so mitigate the virulence of this malady as positively to prevent the pitting or pocking of smallpox.

A failure of the fruit crop in any particularly large area is always followed the succeeding winter by the presence of smallpox. My experience is limited, to eighty-eight cases of that disease in the Pest-House, and my attention has constantly been directed to the establishing of the fact of the non-contagiousness of fomites and to the prevention of the pitting or pocking by the malady. That the pitting or pocking can be positively prevented I am absolutely certain, for in the above number of cases I had only one patient who became pocked — and this was done intentionally. In all of the cases of smallpox that have originated here I have always found bedbugs; and

where patients suffering with this disease were brought here and placed in premises free from these vermin, the disease did not spread to persons living with the patient. This has occurred in many cases, and in all stages of the disease.

My Observations on Bedbugs

By CHARLES A. R. CAMPBELL, M. D.

San Antonio, Texas

The discovery in the year 1880, by Lavaran, that malaria is communicated to the human race by means of the Anophele mosquito; the discovery in 1894, by Kitasato, of the plague bacillus, and, later, that it could be transmitted by fleas; the brilliant work done by Drs. Reed, Carroll, and Agramonte, and by Professor Guiteras, demonstrating that yellow fever is communicated by the Stegomyia fasciata mosquito, have resulted in a most careful and exhaustive examination into the nature and habits of other insects with reference to the probability or possibility that other diseases (the manner of whose transmission has not yet been conclusively determined) may be communicated to the human race by such insects.

Believing that a close relationship existed between variola and bedbugs, I began in the year 1900 to study the nature and habits of the bedbug, and *I* am now of the firm opinion that I have established this particular insect as being the diffusing agent of smallpox.

The bedbug seems to be of a very ancient origin, as I find that it was supposed by the ancient Romans to have medicinal properties, this having been mentioned by Pliny; but I have been unable to find that it was ever known to exist among the Aztecs or the North American Indians or upon any portion of the Western Hemisphere until the advent of the white man. The Romans gave it the name "Cimex Lectularius"—"cimex" meaning a bug, and "lectularius" being simply an adjective, pertaining to a bed or couch.

The bedbug is now such a common insect as to be known to all the inhabitants of the Western Hemisphere, if not of the whole civilized world; and in different parts of the country it is called by different names—for instance, in the State of New York bedbugs are styled "red coats," and they are also called by their ordinary name of bedbugs; in Boston they are generally termed "chinches," or "chintzes;" and in Baltimore they are known by the appellation "mahogany flats." In early English times the common name was "wall louse."

It seems to be reasonably certain that in very ancient times bedbugs were winged insects, and that they flew about from place to place, and even at the present day they retain rudimentary pads, which it is believed, were originally a part of the wings of the insect. It is also believed that as this insect

became more and more closely associated with the human race the necessity for its flying about to obtain its food became less and less, until it gradually lost this means of locomotion.

The bedbug, however, has not lost one of its chief characteristics, viz: its distinct and disagreeable odor, so well known to those that are familiar with it as the "buggy" odor. This peculiar odor is not confined to the bedbug only —a great number of bugs of even different and distinct species possess it; and it is regarded as a means of protection to them against their natural enemies, because it renders them distasteful and obnoxious. Now, the bedbug has none of the enemies any of the other bugs have, viz: insectivorous birds—and its odor is really a detriment to it instead of an advantage, as this odor often leads to its detection. From this it can be deduced that the odor having persisted through the changes already mentioned, extending over centuries of time, the bug still retains it for protection against microbic activities, as doubtless the said odor is due to some antiseptic ether or organic acid.

The hairs which cover the body of this insect are most peculiar from the fact that their ends terminate in two-pronged forks, and when annoyed or teased in the cracks which they inhabit bedbugs will invariably turn around with their backs towards you, so as better to protect themselves from being drawn from the crevices in which they may be located, as each hair presents a distinct anchor, and particularly as against the long feelers of the common cockroach, and also as against the tugging of another one of its most formidable enemies, the little red ant.

The eggs of the bedbug hatch on the seventh or eighth day after being laid, and, if carefully observed, it will be noticed that, within from two to three days before hatching, two bright scarlet spots will appear on the inside and on the exit end of the egg when viable. If these spots do not appear, the egg is not viable. Gasoline, which is so effective in destroying bedbugs, will not destroy their eggs; and, to the chagrin of the careful housekeeper, a new and full-size crop of bugs is again in possession of the bed within a few days after using gasoline. This is readily accounted for by the fact that the eggs can be soaked in gasoline and yet not lose their viability.

In order to make sure of their destruction, I believe that the application of a saturated alcoholic solution of corrosive sublimate, used with constant vigilance, will do the work, as this solution not only kills the adult insects but, by combining with the albumen of the egg, renders the latter sterile.

The ability of these insects to live for a very long time without food of any kind is remarkable. Careful observers have stated that, of their own personal knowledge, houses which have been empty for eighteen months at a time, when again inhabited by people have been found to be so full of these insects as to be untenantable. I have made experiments

which convince me of the truth of this assertion—although the experiments did not run for such a great length of time. I once put a bedstead containing many of these insects into a room by itself, and placed each one of its legs in a can partially filled with kerosene, so as to prevent their escape. After keeping the bedstead locked up in the room for four months, the insects were found in apparently the same condition as they were before the experiment was started.

The ability of bedbugs to remain under water for an indefinite time is also established by the following experiment : I first took a pole about seven feet long, and putting a number of these bugs on one end of it, I placed this end almost at the bottom of a tank containing about five feet of water; immediately the bugs began crawling through the water and up the pole; I then changed ends and reversed the operation, submerging the bugs on top of the pole again in the water, and I continued this operation for five hours without intermission —but to all appearances the bugs were not in the least injured, notwithstanding the fact that, in addition to the submersion, they had travelled a distance of nearly 550 yards.

On another occasion I took some bugs and placed them in a glass receiver, the outlet of which was covered with a piece of gauze. The inlet of the receiver was then placed over a faucet of hydrant water; the water was turned on and permitted to run for five hours; the current of the water forced the bugs against the gauze covering the outlet, and they were thus continuously submerged for that length of time; but, as soon as the stream was turned off and the water removed, the insects showed that they had suffered no injury or inconvenience from the submersion.

One of the characteristics of the bedbug is its cannibalistic nature. It has seven horny bands, which constitute its abdominal cavity, and when it is not engorged these bands lie close together. When, however, it has fed and is thoroughly engorged, it presents a thin membrane connecting these bands, something on the order of an inflated bellows. It is this thin membrane that is pierced by their young, and also by the stronger bugs. Doubtless this characteristic, more than anything else, has served it so admirably in retaining its existence and activity in association with its unwilling host.

One of the most remarkable things in connection with this insect is its powers of resistance to cold. In connection with other investigations I made, in which I believed this parasite was destined to play an important part, it became necessary, in my opinion to determine if these insects could resist a very low degree of temperature, and for a long time, without injury. I, therefore, procured a hermetically sealed glass fruit jar, holding a quart. I then cut round pieces out of a woolen blanket to fit loosely the inner diameter of the jar, and placed a number of these pieces in the jar, together with some three dozen bedbugs, alternating the discs of blanket and the bugs. After sealing the jar so as to exclude water, I suspended it in one of the brine tanks used for making ice at one of our ice

factories; and in a short time the jar was tightly frozen in a two-hundred pound cake of ice. This cake was allowed to remain in the brine tank, where the temperature is only 14 degrees above zero, and the cake stayed as when first frozen for a period of 244 hours. At the expiration of that time, after melting the ice and removing and opening the jar, the insects were found to be in as good condition as when originally placed therein.

The cunning of these insects is most remarkable, and it appears that they have, to a certain extent, the power of reasoning. An example of this kind was given me by Mr. N. P. Wright of San Antonio, a very reliable citizen and close observer. He is ready to make affidavit to the story, which runs as follows: At one time he had all the furniture in his house packed up, except a cot left in one room upon which to sleep, as all of his family were absent on a visit. This cot was placed about one foot from the wall of the room; and, while lying on the cot, he happened to observe a bedbug slowly crawling up on the wall; out of curiosity he watched its movements, and was much surprised to see that when the insect was about four or five feet from the floor— this being about two feet higher than the cot—it apparently sprang from the side of the wall and fell upon the cot. He killed this bug, and thinking that it was merely a coincidence that it should have so accurately alighted upon the cot, he moved the latter another foot away from the side of the wall and resumed his position upon it. After a while he observed another bug crawling up the wall, having come from the base-board. He watched it carefully and noticed that this bug did the same as the other, only that it went up the wall about two feet higher than the first one, and then, with the same kind of a jump as the former bug made, leaped from the wall and fell upon the cot. Mr. Wright continued this experiment, moving his cot gradually away from the Wall each time until it was in the middle of the room, or about ten feet from the wall. On this last occasion one of the bugs crawled up the wall until it got nearly to the ceiling, then gave a jump, floating out like a flying squirrel or aeroplane, and landed upon the cot precisely as did the first bug. This would seem to indicate that bedbugs possess almost human intelligence.

The power of migration of bedbugs is wonderful. I have made experiments at the Old City Hospital (replaced now by the K. B. Green Memorial Hospital) and have positively demonstrated that they will travel the full length of a large ward, and go from bed to bed when these are occupied. I demonstrated this by catching a few bugs and making a tiny mark on each of their backs with an adhesive mixture of balsam fir and flake white, thus marking them distinctly. I then placed them in an unoccupied cot at one end of the ward in the evening, and the next morning discovered them in an occupied cot at the other end of the ward.

Nothing gives the sleeping-car companies more concern than this noxious insect. Here in San Antonio, when a car is being supplied with clean linen, and the used linen is found to

be blood-stained, the telltale "buggy" odor leads to an immediate war against bedbugs, and the car is marked for another crusade in seven days, the officials knowing that another crop of bugs can be depended upon within that time.

Churches—particularly those of the colored folks—schools, second hand goods, and the family laundry, when it is given out and into the hands of an untidy washerwoman, are the principal avenues of dissemination.

A civil engineer in the employ of a railway company was sent to straighten out a large elbow in the railroad, and there being in the vicinity of his work an abandoned section house, he used it as a camping place. One night he awakened by a burning sensation all over his body; and, upon striking a match, he found that his pallet was alive with bedbugs. The weather being very warm, he had placed it in the middle of the room, between the front and the back doors. He picked up his pallet, consisting of quilts and blankets, and gave them a thorough beating upon the front gallery.

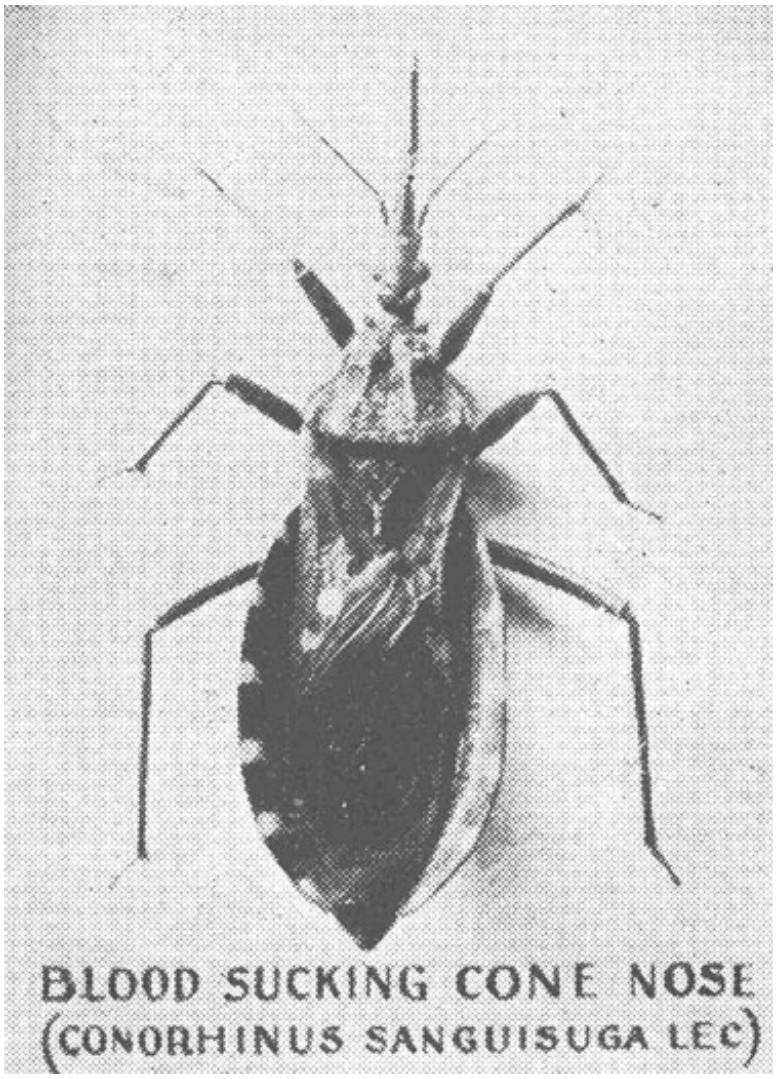
He then replaced it in the same location, but resorted to the larder for protection in the form of a gallon of thick molasses. He made a circle with this around his pallet and went to bed again, with the knowledge, as he thought, that he had defeated the bedbugs. In two or three hours, however, he was awakened by the same burning sensation as before, and upon examination with a light found the bugs dropping right down from the ceiling upon his bedding.

The present or past occupancy of this loathsome insect is easily detected by the stain which its fecal matter leaves on the bed slats, which stain does not appear as a round speck, like that of a fly, but runs along the softer fibres of the wood, in obedience to the chemical affinity between the iron in the fecal matter and the tannic and gallic acids of the lumber.

The study of the bacterial flora of the bedbug is both varied and interesting, and, I believe, is destined to open up unknown avenues for bacterial study of blood, as the work I have done in this direction warrants the opinion that the bedbug will furnish a large field for very interesting and profitable research.

Some years after writing the above "Observations on Bedbugs," which was prepared in 1903, my attention was directed by Mexican farmers living in the vicinity of San Antonio to another blood-sucking insect, which seems to be, in its habit, both nocturnal and diurnal. I was informed by these Mexicans that, in numerous instances, after being bitten by one of these insects at night, the next day a decided malaise was experienced, and this persisted for three or four days, some of those bitten expressing their feelings as a "soreness of the joints." Now, this insect's abdominal cavity will hold from three to four drops of blood, and it is hardly believable that it is the mechanical puncture by the proboscis alone that produced the symptoms mentioned. This insect is called by

the Mexicans *"Chinche Volante,"* meaning flying chinch or flying bedbug. The English name is blood-sucking conenose *(Conorrhinus sanyuisuga).* Almost every Mexican farmhouse has a brush arbor over the front door to afford shade, and it is under these arbors that the Mexicans sleep in the summer, on account of its being too hot in the house. They are then better exposed to the bites of these insects, and wire screening seems to be of no avail in protecting these people from them, as they crawl under the screened door. I have caught a number of them in my own home and screened sleeping room. In some instances they become so engorged that if the sleeper happens to roll over on them and crushes them, a very large blood spot is visible and plainly tells of their presence. In this climate I have found what I believe to be two varieties of this insect. The small squares on the margin of the abdomen in one variety are distinctly black, and in the other variety they are yellow.



"Chinche volante," or flying bedbug

I have had one of these insects photographed and a number

of copies made for distribution among you, so that you will become acquainted with what may prove to be another source of variola in Texas.

It was not my purpose to present this insect to you at this time, and I would not have done so, had it not been for a very fortunate observation I made during one of my pilgrimages in quest of information on the habits of bats.

In looking one day for bats in an old adobe house, on which time had laid a heavy hand—the doors, windows, and roof being nearly gone—I found one of these insects depleting a bedbug. Upon inquiring in the neighborhood for the owner of this house, I learned that it had been vacant for more than twenty-five years, and that it had been built about fifty years ago. Now, bedbugs will continue to inhabit houses for some years after they are vacant, but not for such a great length of time as this one had been empty, not in such a state of decay as this one was in. Such being true, you can readily see the connection which could be established between this insect and a "spontaneous case of variola" where there was no possible contact with the disease, as the *chinche volante* can and will fly long distances.

Eradication of Small Pox by Other Means Than Vaccination

Read before the Bexar County Medical Society

By DR. J. A. WATTS

San Antonio, Texas

In presenting the following experiments, I do not wish to take a stand foreign to the medical profession. I do not pose as a physician who does not believe in the preventive qualities of vaccination nor its practice.

I wish merely to place before you some of the interesting experiments carried out by me during my residence in Mexico. The subject of vaccination has been too well covered for me to discuss its merits or demerits.

Here mention must be made of a few points leading up to the using of other methods than the well-tried mode of local inoculation, vaccination.

Some years ago I became interested in the subject of smallpox through the work going on, as given in the foregoing paper. I was thrown continually in contact with smallpox in the country across the border.

Vaccination by points and serum did not give the desired results, and—

Lastly, the arm-to-arm vaccination adopted by the government of Mexico was out of the question. The lack of care in taking the pus; the disregard to the clinical health of the subjects, and the severely sore arms from mixed infection placed it where my using it was impossible.

I spoke of inefficiency of serum and points. I mean the relative "takes" and non-takes. Keeping close record of all cases vaccinated showed a failure of 80 per cent. This led to an investigation of the serum, which had been obtained from a local wholesale druggist. Direct orders were placed with the laboratories of two houses, but the result proved the same.

Upon the suggestion of one of my fellow practitioners, we wrote to one of the laboratories and got them to prepare a special serum for us; but again disappointment stared us in the face. I never found any satisfactory reason for these failures, excepting the lack of rapid transportation and the consequent changes to which the serum was subjected.

All the time I was trying to stamp out the disease, using all known means, with the exception of isolation, this being impossible, as the government did not impose quarantines.

Being interested in the transmission of the disease, and accepting now the theory of the bedbug as the transmitter, as shown by Dr. Campbell's experiments, I began a redoubled fight to try to rid the community as far as possible of this pest. Where I was able to do this or where I found a house free from bedbugs, I never had a second case of smallpox occur. I allowed and even encouraged free intermingling of families and patients after I was positive that no bugs existed, and in each case had no recurrence of the disease.

The people even go further, trying to produce the disease in their infants, thus procuring immunity for life. To do this, they place them in the bed with the sick and allow them to remain from several hours to a day or so.

In 1907-08 an epidemic broke out in Colonia Minero, across the river from the City of Victoria, also in the town of Xincotencalt. During this epidemic, I mingled freely with my friends, family, patients, and smallpox sufferers. I never employed any of the methods recommended, such as changing, robing, or disinfection during or after visits. I also had the closest possible relations with my boy, who even accompanied me on my rounds when I went to see these cases, he, of course, remaining in the buggy.

I will here state that at that time he had not been vaccinated, this being done in August, 1911, when, upon a visit to San Antonio, his grandfather vaccinated him successfully.

The Hacienda, El Conejo, is used as a halfway house,

everyone stopping there going to and from the railroad station. The manager wrote me regarding the epidemic, and asked me to go down and keep the disease out of the ranch. I began by ordering a general clean-up of the ranch houses, a plastering up of all openings, such as nail holes, cracks, etc., and a remudding of the jacales or mud huts. I used 1 to 500 Bichloride of Mercury in alcoholic solution as an exterminator of bugs and their eggs. Here I practiced vaccination with the usual unsatisfactory results. I allowed a general intercourse between the members of the town and the ranch, but did not allow stop-over-night privileges which would permit travellers to unpack their belongings, nor did I allow the ranch hands to spend the night at the village. The disease never extended to the ranch, getting, however, quite near us in an adjoining ranch owned by Mexicia Haciendados.

From here I was called to Xincotencalt to see the children of the leading merchant. I found three of them suffering with the disease. They were in an adjoining room to the store, the door way between being closed by a calico curtain. The mother and father were continually running back and forth, serving patrons and attending the children. This store was the meeting place for the Chomal Colony, American Settlers, who did their purchasing there. I never heard of any cases occurring in this colony, although, had there been, I should have known it. During my stay here, an oil man came to arrange a business matter with the storekeeper. Upon discovering me there and the nature of the cases I was attending, he wished to get out at once, but I finally persuaded him there was no danger, so he remained. This gave me an opportunity to bring him in contact with the disease, which I did. I then kept him under observation for two weeks, and vaccinated him at Victoria. The vaccination was successful, and it proved he was not immune.

W. E. C. Aged 60. Seen first in stage of invasion; rash broke out measley at first. On the third day I vaccinated his boy. A few days later the lad developed a light case. I then began my bedbug killing and cleaning-up process. The mother gave a history of having had the disease. I allowed free intermingling of this boy with his playmates, and no cases developed in any of them.

L. R. Aged 20. Seen in initial stage. I remudded his house and cleaned it up with Bichloride Solution. No case developed among any other members of this family, although three children, his wife, and his brother's wife and mother lived there. Also about twenty relatives visited him during his illness. All of these were my patients and personally known to me.

Child 4 years of age. Contracted the disease on a visit to San Luis Potosí from Cerro de San Pedro. This family lived in a cave. This I cleaned up by drenching it with Bichloride Solution. A few days later a ease developed in an adjoining cave. Upon investigation I found a communication between the two caves. This I closed and cleaned up the second cave.

After this I had no more trouble.

V. B. Aged 19. Puerto Zuelo; seen in convalescence. Second case developed across the street in a baby ten months of age (Fades Ojedo). The mother of this child, who was a relative of the first case, had been nursing the said first case, (probably produced the disease in her child). I cleaned up both houses and had no more cases in this village.

C. C. Aged 10. Well developed case when first seen. I ordered the house cleaned up under police supervision. His brother developed the disease three days afterwards, but no other case occurred here, although three girls, the mother, and the grandmother occupied this cave.

Case, 6 months child of R. P., mine foreman, developed smallpox at the same time as a young girl waitress at one of the fondas or restaurants up town. I found that this girl had been in the habit of playing nurse-maid to the baby after working hours. I did my usual extermination stunt here, and no other case developed.

J. F., boy of twelve months. Same precautions used. No other case developed. This family consisted of two other children, mother, and father.

R. L. Aged 20. Developed after a visit to San Luis Potosí. He lived with his brother, an alderman of Cerro, San Pedro, whose family consisted of four children, wife, mother, and sister. I found no evidences of bugs here, but took the usual prcautions, and upon my advice we kept the children here during his brother's illness. No other case developed.

J. A. Aged 1 year. Some ten children lived here in three rooms. After several hours of hard work at extermination and cleaning up I was rewarded by no new cases developing here.

Following the presentation and discussions of this work, these resolutions were adopted by the Society:

"WHEREAS, the Bexar County Medical Society remembers with satisfaction its hearty endorsement of Dr. Chas. A. R. Campbell's original work in proving that the bat is the natural enemy of the mosquito, which is now being widely accepted as a scientific fact;

"RESOLVED, That we express our entire confidence in Dr. Campbell's experiments and clinical observations tending to show that the bedbug is the sole conveyor of smallpox, as the body-louse is of typhus fever, and we believe that further experience will lead to its complete demonstration.

"RESOLVED, further, That in the interest of scientific progress, a committee be appointed by the chair to pursue a careful investigation of the subject in conjunction with the Board of Health, and that this Society tender its cooperation in the matter, and in framing the proper regulations for the control and eradication of the pest." The committee consisted

of the following gentlemen:

Drs. J. S. Langford, J. A. Watts, T. T. Jackson, D. Berrey, Chas. A. R. Campbell, and S. C. Applewhite.

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PART IV

The Functions of the Spleen

(A paper written in October, 1923, and delivered, before the Bexar County Medical Society on February 21, 1924.)

DEDICATED TO THE PEOPLE OF ITALY

At a regular meeting of the Bexar County Medical Society held on October 23rd, 1919, at the suggestion of the author, the following memorandum was entered in the minutes of the Society:

"It has been my good fortune to make a discovery, which, coupled with my experience in malaria, has led me to the following conclusions:

"That the spleen, which has so long baffled and been a puzzle to the physiologist, is given to man primarily as a defense against malaria. In other words, the spleen contains the defensive agent or hormone hostile to the malarial parasite, which enables it, first, to resist the initial invasion, thus accounting for immunization; and, second, to resist the influence of the continued residence of the parasite in the body.

"That its enlargement is physiological and a prima-facie evidence of a malarial invasion.

"The above is founded on my experience in malaria; and the discovery (which harmonizes entirely with the laws of Nature) of the fact that to the bat, whose food consists principally of blood containing the malarial parasite, which it gets from the malarial mosquito in all the different phases of evolution, Nature gave a spleen relatively 4.25 times as heavy as the spleen of man for its conservation and for its protection from the malarial parasite."

With a view of demonstrating the gist of the foregoing memorandum, I present this theory for your consideration and criticism, and advance it with the statement that this particular malady, known by the misnomer of "malaria," is a "physio-pathological" condition, in that it is so divergent from the bacterial diseases, because it is a scheme of Nature for the human being, and the human being only, to carry and diffuse. It goes without saying that it is a disease, in that it causes pathology without end, but what gives it its physiological aspect is that asexual cycle of the parasite occurs in the body

of man; and then he, being provided with a special defense conserving himself against the parasite, thereby permits and insures the continuance of that particular form of life, as well as the life of himself, the host, through which it is perpetuated, and also confers on the parasite a special exemption or immunity from the phagocytes.

In making the assertion that malaria is a "physio-pathological" condition, that assertion must be founded on, or at least harmonize with, the ordinary laws of Nature, which are a matter of common knowledge, or else it will fall flat.

It is a matter of common knowledge that when Nature intends one creature to be preyed upon by another, she gives the creature preyed upon some defense against its enemy; for otherwise, the creature preyed upon would soon become extinct, as would also the creature it was intended to nourish. Ordinary reasoning makes this conclusive, as Nature does not defeat her own schemes.

As the author confines his private practice exclusively to malaria and typhoid fever (the latter on account of its being so frequently associated with malaria and being such a powerful complication), it is but natural that he should give this world-wide disease a great deal of thought and concentrated attention.

The occasion for launching this theory was brought about whilst the author was dissecting bats in the study of their anatomy, for he was particularly struck with the enormous size of the bat's spleen, as compared to the size of its other internal organs. The weight of a bat's spleen is relatively four and twenty-five hundredths times heavier than the spleen of man. This observation opened a wide field for thought, and threw a bright little beam of light, which, with reflection and study, was converted into a refulgent ray, illuminating one of Nature's mysteries.

Considerable of the current knowledge of the physiology and anatomy of the spleen gives us valuable clues, which adapt themselves to the theory here advanced.

Anatomically, at birth, its weight in proportion to that of the entire body, is almost the same as that observed in the adult. This would lead us to conclude that the spleen of the newly-born infant is provided with its hormone ready to defend its host, because at all times, beginning with birth, is a human being subject to infection by an infected anophele. This fact gives to the theory great force; and if it were not a fact, the theory would be just as greatly weakened.

To quote from Gray's Anatomy, a recognized authority:

> "The arterioles terminate in capillaries which traverse the pulp in all directions; their walls become very much attenuated, lose their tubular character, and the cells of the lymphoid tissue of

> which they are composed become altered, presenting a branched appearance and acquiring processes which are directly connected with the processes of the sustentacular cells of the pulp. In this manner the capillary vessels terminate, and the blood flowing into them finds its way into the interstices of the reticulated tissue formed by the branched connective corpuscles of the splenic pulp. Thus the blood passing through the spleen is brought into intimate relation with the elements of the pulp, and no doubt undergoes important changes."

Furthermore, to facilitate these changes, the splenic artery is remarkable for its large size in proportion to the dimensions of the organ, and for its tortuous course. Not only is the size of the spleen entirely in harmony with its functioning,—viz: permitting a large amount of blood to flow into it in order for it to become charged with its protecting hormone, but the fibre-elastic coat forming the framework of the spleen permits it greatly to enlarge, thus enabling it to do more work as conditions arise and demand. This fact again gives to the theory as much force as it would weaken it, if it were not so. One of the most remarkable points in the anatomy of the spleen is that the arteries scarcely anastomose in. order for the blood slowly to find its way into it, while the veins, in order to facilitate the return flow of hormonized blood, are notoriously supplied with anastomoses.

It may be possible that the spleen destroys a certain number of infected corpuscles, allowing the leucocytes to remain, in order to remove the debris. This would account for the richness of the leucocytes in the spleen.

There is an abundance of evidence to demonstrate that the spleen is not a blood-making organ, as no disturbance in the digestive functions follows its extirpation.

Austin Flint, Jr., in his work entitled "Human Physiology," on extirpation of the spleen says:

> "There is one experimental fact that has presented itself in opposition to nearly every theory advanced with regard to the use of the spleen, which is that the organ may be removed from the living animal, and yet all the processes of life go on apparently as before. The spleen is certainly not necessary to life, nor, as far as it is known, is it essential to any of the important general functions. It has been removed from dogs and cats, and even from the human subject; and its absence is attended with no constant and definite changes in the phenomena of life."

In substantiation of the above, cases are on record of the congenital absence of the spleen in the human subject, in which eases no special phenomena had been observed during

life. This would lead us to conclude that the spleen, having no particular functions to perform in the processes of life, was given by Nature to man and certain mammalia for protection against the particular hemameba she causes them to carry.

And indeed it would be singularly peculiar and out of the infallible order of things in Nature, if she did not do so; as, if she did not give some protection to the human from the malarial parasite, which it is one of her schemes for the human to carry, the human would be overwhelmed by the parasite, which in turn, would be overwhelmed by the perishing of the host, and thereby Nature would defeat her own aims.

Such a turn of affairs in Nature has not been known, at least not during our short lives. That the parasites do overwhelm the human, just as they destroy the mosquito in the cycle of sporogony by their overwhelming numbers, is a matter of common knowledge to the profession, but these are isolated cases, rather than the rule.

That the spleen normally enlarges after each meal also supports the results of this study, as it is for the purpose of hormonizing the resultant new blood, thereby performing its function.

A striking illustration, in support of the assertion that malaria is a "physio-pathological" condition, is seen in the manner in which Nature causes this parasite to find its normal habitat in the body of man, in that it makes its life-cycle intra-corpuscular. As soon as the sporozoit is injected into the blood of the human by the mosquito, it immediately enters the red corpuscle where it is perfectly ensconced and safe from the leucocyte.

All of its life-cycle takes place in the red corpuscle, hence its freedom from attack by the natural defenders of the body. It is only after the period of sporolation, when the parasites (merozoits) are free in the blood-stream, that the leucocytes can, and do, attack the parasites; a large number of them, however, escape the defenders, re-enter the red corpuscles, where they are again safe from their enemies, the leucocytes, and ready again to begin their cycle of schizogony. By this phase of the evolution Nature asserts her wonderful balancing powers, which serve to perpetuate her various forms of life through the varying vicissitudes to which she causes them to be submitted.

The asexual life of the parasite occurs in the body of the human. As it is he who furnished the "seed" (gametes) for the perpetuation of its life, and as the seed is such a powerful factor in the perpetuation of life, Nature again asserts herself by granting the gametes special immunities, in that, in the human, they are not strictly intra-corpuscular, they are not a foreign body in the eyes of the Great Force, and consequently are immune from phagocytic attack. But the "seed" has to pass on to another creature, the malarial mosquito, to undergo the

true sexual evolution; and here again Nature continues the protection, as all the elements of the blood that the mosquito ingests are digested by her, except the gametes.

It is quite understood that the mosquito is not in the least concerned about the life of the malarial parasite, as, when she bites, it is with the view of obtaining her natural food; and she is not at all concerned in the perpetuation of another form of life. This is Nature's concern, and we see how well she takes care of her work when we contemplate the enormous prevalence of malaria the world over.

The enlargement of the spleen in malaria, which is conclusive evidence of a paludic invasion, is nothing more nor less than what is to be expected, as the said enlargement renders it more fit to perform its functions by allowing a larger quantity of blood to enter its structure. In fact, its enlargement, which is concomitant with the sporolating phase of schizogony, and its remaining enlarged for a considerable length of time without undergoing degenerative changes and then reducing itself to its normal size, give it a plain physiological significance.

The enlargement of the spleen depends entirely on the greater or less severity of the malarial invasion. In notoriously malarial regions the splenomegalys are very common on account of the great prevalence of infected mosquitoes; and continued reinfections keep the spleen enlarged in its endeavors to perform its functions, viz., excreting its hormone, which is inimical to the malarial parasite, and neutralizing its toxins.

The spleen being much overworked, it is but natural that it should lose the great bulk of its hormone; and the infected individual, finding himself without the protecting agency with which Nature intended him to be provided, soon lapses into serious pathology, in which the blood is first concerned, the physiology and chemistry of that tissue being so disturbed that the blood-making organs revolt at the quality of nutrition they are receiving, and endless pathology of a very severe nature usually follows.

Its enlargement—that is, when it cannot only be readily palpated but very plainly seen in its left hypochondriac region—is due to its being overworked, with the consequent loss of its hormone. This is evidenced by the fact that the administration of the powdered spleens of animals, PROPERLY SELECTED, will cause its reduction in an astonishingly short time. The words "properly selected," have a deep significance, and their importance will be shown later on.

The so-called "Lord of the Universe" is no more in favor with Nature than are any of her other creatures, from the lowest to the highest; and, if we turn to the bovine family, we shall find a most perfect analogue furnishing convincing evidence in favor of the results of this study.

In this species of mammals, Nature has seen fit to perpetuate another form of parasitic life in the red corpuscle of that creature, the disease to which it gives rise being known as babiosis, or familiarly as "tick fever," or sometimes as "malaria in cattle." Here the tick plays the same role in the bovine family that the mosquito does in the human family. This particular form of parasitic life, known as the piroplasma, thrives in the bodies of cattle, *and in the bodies of cattle only,* just as the plasmodia finds its normal habitat in the human being, *and in the human being only.* None of the domestic or the wild animals carry malaria, neither do any of the wild animals carry the piroplasma which cause the tick fever in cattle.

An infected mosquito cannot infect an individual of the cattle species; and it is very doubtful as to whether an infected tick can convey the tick fever to man. There are many species of ticks, but only one species conveys the tick fever to cattle, just as there are many species of mosquitoes, but only one species transmits malaria to the human.

In cattle with the tick fever the same pathological changes take place in the blood-making organs as do in the human being infected with the malarial parasite. This the author knows from actual observations in the slaughter houses. In fact, the analogy is so perfect, that if some enthusiastic student having the time and money and love for original research in the interest of mankind and science, would establish a thorough, systematic, and scientific study of babiosis, he would have plenty of material to work on, from the embryo to the adult; and the knowledge so gained would apply most fittingly to malaria in the human.

In the tick, a cycle of evolution takes place on the part of the parasite, similar to the cycle of evolution that takes place in the body of the mosquito. In the red corpuscle of cattle, a cycle of evolution takes place similar to that of the cycle of evolution that occurs in the red corpuscle of man.

In the parasitisms, or "physio-pathological" conditions, in both the human and the bovine families, we see how strictly Nature draws the line as to the food of her parasites, in that the piroplasma will not develop in the blood of any other creature that the infected tick may happen to be feeding upon. The tick itself finds nourishment, but the parasite does not, consequently its life's cycle is arrested, and it perishes. The mosquito finds nourishment in any kind of blood, but the malarial parasite she carries finds nourishment in human blood only. In tick-infected pastures or ranges, none of the wild animals there, such as the deer, which mingle freely with the cattle, particularly at the salt licks, acquire the tick fever, neither are any of the domestic or wild animals infected with malaria by an infected malarial mosquito.

At first glance it would seem that, in the perpetuation of parasitic life, Nature gave the mosquito an advantage over the tick, in that it flies from host to host, while the tick hatches on

the ground and has to await the coming to it of its host. Truly, the tick does not fly from host to host, as it has no wings to fly with; but, unlike the mosquito, the egg of the tick is infected before it is hatched, which makes up for the non-flight, and so most unerringly does Nature continue that particular form of parasitic life.

When an individual of the bovine family is bitten by an infected tick, it acquires the tick fever, and, like the human being, the development of the acute form depends on the number of parasites injected, plus the condition of nutrition and environment. If it recover from the acute form, it is referred to by the cattle owner as being "immune," which is very much in error, as the animal now has the disease in the chronic form, just as the human being has malaria in the chronic form after passing through an acute attack; and both the human and the bovine families are the disseminators of their respective parasites in their respective ways,—or, in other words, they are obeying the inexorable laws of Nature.

In the body of man, malaria need not begin with the acute form in order to exhibit its chronicity; fever need never have been a necessary accompaniment of a paludic invasion. Perhaps the same condition holds good in cattle.

If we should encounter a rosy, well-nourished individual, showing not a single trace of the cachexia, we should be inclined to think that he was in the enjoyment of good health until he tells us that at times he suffers with severe "headaches." An examination of his blood will perhaps show negative, but his migraines or hemicranias give the tell-tale periodicity, overshadowing the most unsatisfactory of diagnostic methods, the microscopic.

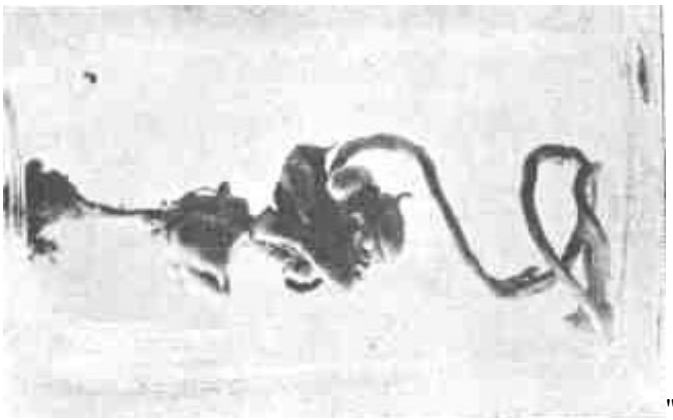
If we select from a good-sized herd of cattle the healthiest, sleekest-looking animal, one that we have seen on foot in a playful mood, on post-mortem examination we shall find with but little difficulty the tell-tale enlarged spleen, and also the piroplasma in the blood from the spleen. In both instances it is by the spleen that the pathology has, at least for a time, been held in leash through the protective hormone secreted by the spleen; but, again, both are disseminators of their respective parasites, and are obeying the laws of Nature.

The author desires to state that his observations of the spleen in cattle have been limited to animals slaughtered in this vicinity (San Antonio), such as cattle, pigs, goats, and sheep. As to other localities he has no data.

That the chemistry of the spleen in man is identical with that of the spleens of the ordinary food animals, is evidenced by the fact that the human spleen will readily replace its exhausted condition by the administration of any of the spleens or splenic extracts of the animals mentioned, provided the spleens employed are normal.

This was mentioned in one of the preceding paragraphs;

and emphasis was laid on the words "properly selected." The author has had considerable experience in the treatment of very poor Mexican children, having chronic malaria, with splenomegaly; and in several cases the ordinary spleen extract found in the drug stores was used without perceptible results.



"

Digestive System of Bat, from Larynx to Anus. Note the large spleen between the arrows."

Bat's Skull.

Spleens from young pigs and goats were then procured in the slaughter houses, salted, and dried in the same manner that beef is dried—by being hung on a line in the sun. When dried, this parchment-like substance is pounded into a powder; and as much powder as a dime will take up, being held between the fingers at the edge, is given to the child four times a day—(this amount will weigh four or five grains). In an astonishingly short time the spleen resumes its normal size,

and the pot-belly subsides.

To secure "properly selected" spleens one must avoid the bovine spleens, as hardly one per cent of them are normal, showing the extreme prevalence of the piroplasmic infection in cattle; and it is nothing but what we ought to expect, as they live "under the open skies," or next to Nature, thereby facilitating the obedience to Nature's laws. Their higher contemporary would be as highly infected with his parasite, if he lived under the same conditions.

It goes without saying that the powdered spleens, or splenic extract made from animals with babiosis, is even more than worthless, as the very substance desired has been exhausted in an enlarged spleen for, otherwise, it would not have been enlarged. This would account for the failures some of us have had in prescribing some of the spleen extracts found in the drug market. In order to procure the best results in the administration of spleen substance, the spleens should be removed from young pigs, sheep, or goats, and thoroughly examined by some competent veterinarian, and a long time after the animal has fed—or, better said, before feeding time, as it is then that the spleen is richest in its hormone, and begins to enlarge and expend the same in the performance of its physiological function.

As a portion of these studies—particularly the analogue of malaria in cattle—comes under the realm of animal medicine, I desire to return thanks to Dr. Ingild Hansen, a highly learned Danish veterinarian, U. S. A., retired, for his hearty co-operation and advice.

One of the most distressing experiences in the treatment of malaria is to encounter a patient with an idiosyncrasy against quinine. Such individuals suffer a great deal; and their health becomes seriously undermined because of their being deprived of that most valuable of therapeutic agents. If this study should arouse in the mind of some enthusiastic physiological chemist the desire to set for himself the task of isolating the hormone from the spleen, and if he should succeed, it is very much within the realm of possibility that he will not only have conferred a boon on his fellow man, but perhaps will have given to the world a therapeutic agent superior to quinine.

It is the bat, which the author has been studying for a period of twenty-one years, that gives strong testimony in favor of the theory, and it would perhaps be fitting to quote from these studies some points having a bearing on this argument. The species studied so intensely by the author is the common free-tail bat—*Nyctinomous Mexicanus*—but what has been learned of this species applies to all others of the small varieties. In Mexico all the small bats are called *"murcielagos mosqueteros,"* meaning mosquito bats,—so well and so long have the natives understood their habits.

The enlarged photograph of a bat's skull proves it to be

distinctly carnivorous. A glance at the dental formula shows the prominent canine teeth, but the molars differ from the molars of the carnivora, in that they are chopping teeth instead of grinding. The value of this provision is readily seen when we take account of the fact that the bat procures its food in the air, and, if it had to grind it like a cat or dog does, the food would fall out of its mouth and be lost. The mosquito, being a blood-sucking insect, and its abdomen being engorged with blood, affords the bat an ideal carnivorous diet.

As it matters not to the mosquito from whom she gets blood, whether from the human or the bovine family, from the dog, coyote, deer, or what not, it does matter, and is of vital concern, to Nature, in that in the blood which the mosquito gets are different forms of parasites taken from the different creatures from whom she procures it. It is this parasitic-laden blood, with its concomitant toxins, which she causes to be wholesome to the bat; and she provided the proper protection when she gave that creature such an enormous spleen.

It would be, indeed, strange, if Nature should have found other means than the spleen to protect the bat, when she already employs that method in some of her other creatures. This again supports the assertion that the chemistries of the spleens of man and of animals are so nearly identical. The spleen of a bat protects it from any and all of the different hemameba, and from toxine-laden blood carried by the different creatures in which they find a normal habitat, and which the mosquito ingests, in turn to be ingested by the bat.

The studies already referred to show the bats to be remarkably free from disease, notwithstanding the fact that they live in caves with no ventilation, in the midst of their own excretions, and in an ammoniacal atmosphere created by the decomposing guano. The longevity of the bat is accounted for by the absence of a colon.

In studying the scatology of bats, chemistry reveals the kind of food the creature subsists upon, and very conclusively shows the enormous amount of blood the bat consumes. In fact, it might be said from the figures that follow, that the bat has a selective instinct for finding the engorged mosquito. One ton (2000 pounds) of bat guano contains three pounds of iron. This is the valuable point, and these are the figures that give it a firm foundation. This estimate is founded on the fact, as will be noted in the current text books, that haemoglobin contains 0.42 per cent of iron, and blood contains 15 per cent of haemoglobin.

With this information in hand, we find that three pounds of iron are the ferric content of 4761 pounds of liquid blood. Sixty-seven per cent of bat guano consists of chitin, and this *per se* contains 0.85 pound of iron, which is the ferric content of 1349 pounds of blood. Of course, this 0.85 pound of iron and the ferric content of 1349 pounds of blood it represents, must be deducted from the three pounds of iron and the 4761

pounds of blood. In order to be very conservative and to avoid any possible source of error, let us deduct 0.15 pound of iron as being derived from the ten per cent of the food of bats other than mosquitoes, small plant-sucking insects which would carry some iron from the green coloring matter of plants (chlorophyl) and which is the ferric content of 237 pounds of blood.

Thus far we have accounted for one pound of iron and the 1587 pounds of blood it represents. We still have two pounds of iron, which is the ferric content of 3174 pounds of blood. Reduced to smaller figures, each pound of bat guano represents *more* than one and one-half pounds of liquid blood. More, it is said, because after the mosquito has had her fill of blood, and while at rest digesting her meal, in order to concentrate her food, she voids the liquid portion of the blood *(liquor sanguinis)* and, of course, this does not figure in the chemical determination of the iron content in the bat guano.

The enormous good the bat does and the wonderful benefit it is to us almost baffles the imagination, when we contemplate the uncountable number of mosquitoes, each with its tiny droplet of blood in its tiny abdomen, that the bats must catch, in order for each pound of bat guano to represent more than a pint and a half of liquid blood. It arouses in our minds "a feeling akin to pain," with a sense of guilt, at having had for, lo, these many years, such a valued friend doing such wonderful work for us, and we unconscious of the fact.

In the bat roost already described and which the author calls his Mitchell's Lake bat roost, approximately two tons of bat guano are gathered every year; and, as we have seen, this represents 6348 pounds of liquid blood. This however, is only the guano dropped on the inside of the roost during their resting hours, or the day, and does not take into account the guano dropped in the open by the bats during their hours of feeding, which ordinary reasoning assures us to be at least again as much. Thus we see that the tenants of this little building consume enough mosquitoes in one year to make up 12,696 pounds, or more than six and one quarter tons of liquid blood, and these astounding statements are not founded on the experiments, statements, or observations of any person, but on the solid and immovable foundations of SCIENCE.

In conclusion, I hope you will pardon me when I digress from the subject matter to say that it has been one of the most ardent desires in my professional life to arouse the laity and create public opinion on the seriousness of this "physio-pathological" malady, malaria, which is now regarded with so much levity; and if you are of the same opinion, and will use all of your influence and power to that end, you will add lustre and garlands of laurels to that noblest of all the professions, of which I have the honor to be an humble member.

N. B. Since the preceding was set up in type, there has been received a lengthy resume of this paper on the spleen published in the June, 1925, issue of the *Giornale di Medicina*

Militare, issued by the Ministry of "War at Rome, Italy. This recognition is a realization of one of the author's fondest hopes.

Glossary of Terms

- Acrid—An irritant, corrosive poison.
- Aeolus—The God or keeper of the winds.
- Agrionidae—A family of neuropters comprising the vari-colored dragon flies.
- Albuminous—Of, pertaining to, like, characterized by, or consisting of albumin or albumen.
- Algae—Green, brown, or red aquatic cryptogamous plants occurring in both fresh and sea water.
- Alimentary canal—The passage extending from the mouth to the anus, in which food is received, digested, and assimilated.
- Allegation—A formal assertion.
- Alkaline—The opposite of acid—extended to anything that will neutralize an acid.
- Anemia—Deficiency of blood or of red corpuscles.
- Anophele—The malarial mosquito.
- Antennae—Aerial collecting wires. Appendages to the head of an insect.
- Antiseptic—Anything that destroys or restrains the growth of germs.
- Anus—The opening at the aboral extremity of the Alimentary Canal through which the excrement is expelled.
- Arterioles—Little arteries.
- Babiosis—Texas fever; tick fever in cattle.
- Bacteria—The smallest of all organized forms of life.
- Cachexia—An acquired constitutional perversion of nutrition.
- Capillary—A minute blood vessel, like a hair.
- Centrifugal—Directed or tending away from a center.
- Chitin—The horny outer covering of all insects.
- Coagulation—A clotting.
- Colon—The superior part of the large intestines.
- Comminuted—Reduced to minute particles of powder.
- Concomitant—Any thing or event considered as accompanying or coexisting with another.
- Congenital—Existing from birth; innate.
- Contagious—Transmissible by contact; catching.
- Corpuscle—Minute body. Cell.
- Desquamation—Scaling of the cuticle.
- Diagnosis—Recognition of disease from its symptoms.
- Duct—A tube to convey a liquid.
- Effete—Worn out and incapable of further production, for instance, referring to the soil, an animal, or a plant.
- Empyrean—The upper sky; also cosmic space.
- Endemic—Peculiar to or prevailing in or among some (specified) country or people.
- Epidemicity—The quality of being epidemic.
- Excretion—Any waste matter discharged from the system.
- Excretory—Pertaining to excretion.
- Extirpation—Getting rid of, as by taking out by the roots. Destroying wholly.
- Fauna—The totality of the animals inhabiting a given area, or existing within a given period.

- Ferruginous—Containing, or having the nature of, iron.
- Fibro-elastic—Character of a tissue made up of both white-fibrous and yellow-elastic connective tissues.
- Flora—The totality of plants growing without cultivation in a country or district.
- Foci—Plural of focus, which is a point of meeting of a series of lines.
- Fomites—A substance capable of retaining contagious germs and thus propagating infectious disease, such as carpet, bedding, etc.
- Gametes—The sexual reproductive cells of the malarial parasite.
- Gestation—The act of carrying eggs or ova, especially of carrying a fetus in the uterus; pregnancy.
- Gland—An organ which eliminates from the blood or adds its substance thereto.
- Gregarious—Having the habit of associating in flocks, herds, or companies.
- Gyrate—To revolve, especially in a spiral or helix, as does a cyclone.
- Hemameba—An ameboid parasite inhabiting the blood. Hemoglobin —The red coloring matter of the blood.
- Hibernation—Passing the winter season in a secluded place and in a torpid state, as do certain animals.
- Hormones—Secretions of glands having excitant properties.
- Hygiene—Sanitary science.
- Hygiostatic—(Coined word) meaning "Standing for Health."
- Hypochondriac—One who is morbidly depressed or causelessly anxious about his health.
- Hypodermic—Of, or pertaining to, the area under the skin.
- Immunization—The act of making immune, for instance, protecting from infection by inoculation.
- Infectious—Capable of communicating disease, as by entrance of pathogenic germs into an organism in any manner.
- Ingest—To put or take into the stomach.
- Inject—To introduce a fluid by injection; as, to inject morphine hypodermically.
- Macerated—Reduced to a soft mass by soaking or digestion.
- Mammal—A vertebrate animal whose female has mammae, or that suckles its young.
- Mammalian—Of or pertaining to mammals.
- Melanine—A pigment generated by the malarial parasite.
- Merozoit—The next to the last phase in the evolution of the malarial parasite in the body of the mosquito.
- Meteorological—Of or pertaining to meteorology or atmospheric phenomena.
- Microbes—Synonymous with germs, bacteria, etc.
- Micro-organism—Same as microbe.
- Migrane—Neuralgia of half of the head.
- Mucus—The viscid liquid secretion of mucuous membranes.
- Orientation—The determination of. position with reference to the points of the compass.
- Oviposit—To lay an egg or eggs.
- Palpation—The process of examining or exploring morbid conditions by means of touch.
- Paludic—Of or pertaining to a marsh or swamp.
- Parasite—An organism, either an animal or a plant, that exists on or in some other organism.
- Pathological—Pertaining to disease in living things.

- Phagocyte—A white corpuscle that takes into its substance and digests bacteria and other noxious matter.
- Physiological—Pertaining to the functions of living organisms.
- Physio-pathological—(Coined word) meaning pertaining to both health and disease.
- Piroplasma—A blood parasite inhabiting the red corpuscles of cattle.
- Plasmodia—A blood parasite inhabiting the red corpuscles of man.
- Prepuce—The foreskin of the penis.
- Protozoan—A primary division of the animal kingdom variously ranked and limited, embracing organisms consisting of a single cell or group of cells not separated into different tissues.
- Reticulated—Meshed.
- Retinal—Pertaining to the retina or internal membrane of the eye.
- Salivary—Pertaining to the saliva or spittle.
- Schematic—'Pertaining to or of the nature of a general plan.
- Schizogony—The cycle of evolution on the part of -the malarial parasite that occurs in the body of man.
- Scorbutus—Scurvy; an acquired constitutional perversion of nutrition due to errors in diet.
- Seepage—The oozing or percolation of fluid; or the fluid or moisture that oozes.
- Serum—The more fluid constitutents of blood, lymph, etc.
- Skeletal—Of or pertaining to the skeleton.
- Splenomegalia—Enlargement of the spleen.
- Sporozoit—The last phase in the evolution of the malarial parasite that occurs in the body of the mosquito.
- Sporulating—Developing spores.
- Sustentacular—Sustaining, supporting.
- Therapeutic—A medicine efficacious in curing or alleviating disease.
- Thoracic—Pertaining to the thorax.
- Toxines—Poisonous compounds of animal, bacterial, or vegetable origin.
- Variola—Smallpox.
- Ventral—Of, pertaining to, or situated on or near the abdomen.
- Viable—Capable of maintaining life.
- Volplane—To swoop toward the earth from a height at an angle considerably greater than the gliding angle.

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